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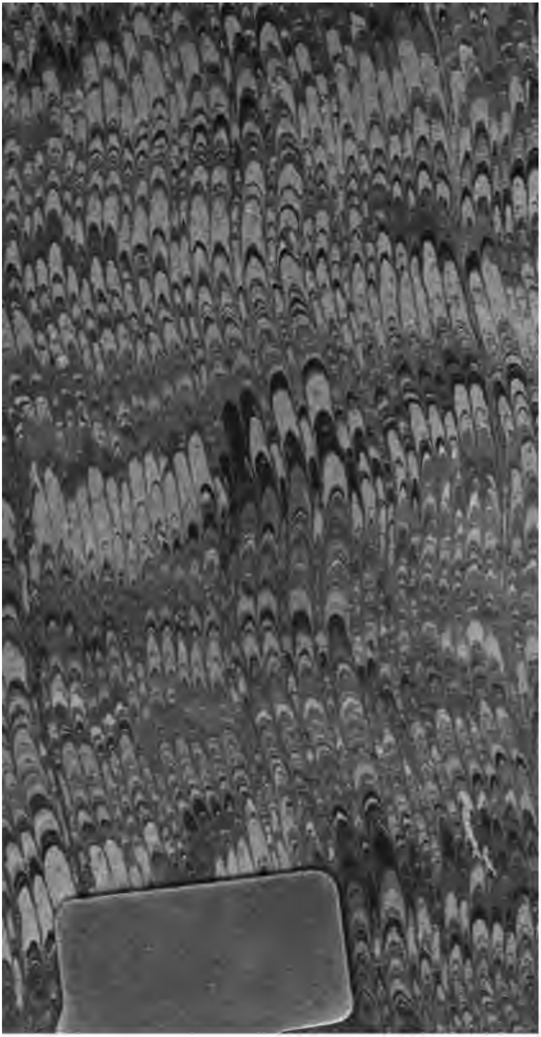

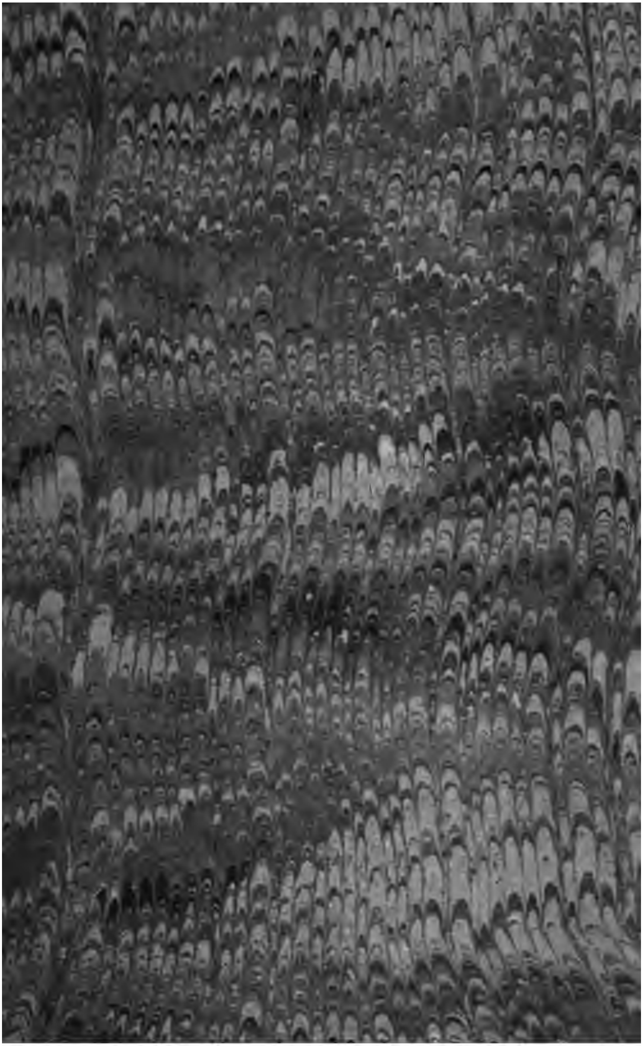

44. 959.

THE
BRITISH GUNNER.

BY

CAPTAIN J. MORTON SPEARMAN.

> "EN RETRANCHANT LE SUPERFLU, ON APPREND MIEUX LE NECESSAIRE."
>
> MONTÉCUCULI.

Third Edition.

REVISED AND ENLARGED.

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TO

FIELD MARSHAL

THE DUKE OF WELLINGTON,

IN WHOSE SPLENDID ACHIEVEMENTS

The Royal Artillery

HAVE FOUND

THEIR BEST SCHOOL OF PRACTICAL SCIENCE;

THIS LITTLE VOLUME

IS RESPECTFULLY INSCRIBED,

BY

HIS GRACE'S

OBLIGED AND OBEDIENT HUMBLE SERVANT,

THE AUTHOR.

PREFACE.

A POCKET Manual of Artillery having already been, for many years, in very general use in the Ordnance Service, it will perhaps be expected that I should shortly explain why I have ventured to publish another little work on the same subject.

It would be absurd to claim an hereditary title in the 'Pocket Gunner'; but I may be permitted to feel an hereditary interest in a subject which engaged my father's professional attention, and was principally illustrated by his labours. The 'Little Bombardier and Pocket Gunner' was first published in 1801, and was compiled by the late Major Ralph Willett Adye. I have in my possession my father's papers, from which a very material part of that work was composed; the passages extracted being marked in his handwriting, for that purpose.

In 1802, a second edition of the 'Bombardier and Pocket Gunner,' revised and corrected, was published, with the name of the compiler on the title page, The memoranda for this improved edition were also, to a great extent, furnished by my father; who, however, declined any mention of his name, or share in the work. It afterwards went through four impressions, without material alteration. Major Adye died in 1804, and in 1808, my father.

Major Eliot, in 1813, prepared a seventh edition, in which, however, he only partially inserted some of the details of the improved practice which experience had suggested; and in 1827 he published an eighth edition; but in this also, while much obsolete matter was retained, many of the improvements, to which the advanced state of the service had led, were entirely omitted.

It was suggested to me, by some of my military friends, that I should undertake to compile an improved work. I was satisfied, from my own observation, that this might be done, and I have therefore attempted it. I am quite sensible that much yet remains to make this work complete; but I trust that my little volume is not altogether unworthy of approbation, as an attempt to afford to the profession, information on many points of importance, which have been altogether omitted in the former work.

I thought it very desirable that a work of this kind should contain not only the practice of Artillery and Engineering, as was the case with the 'Bombardier and Pocket Gunner,' but also some elucidation of the theory of those sciences; and

I have therefore introduced several scientific papers on these subjects.

Besides, undertaking to correct the errors of obsolete rules, and to enlarge and extend the quantity of useful information with which such a book should assist the practice of the professed artillerist, I have farther endeavoured to make the present volume of some worth, on other points, to individuals in the lower ranks of the Artillery, as well as to the junior members of the service in general.

An acquaintance with the first principles of fortification,—as well permanent as field,—is indispensable to every officer; because there are none who may not be called on, in the exigences of the service, to direct or assist in the construction of field-works, temporary bridges, gabions, fascines, etc. It is therefore presumed, that a few practical rules, applicable to these various departments of professional science, and mechanical labour, may not be found unacceptable or useless. It is acknowledged that this sort of information has not yet been satisfactorily given in a portable compass; and I venture to hope, that, in an endeavour to supply it, it will be found, I have not been altogether unsuccessful.

In compiling the "British Gunner," I have received great assistance from many of my military friends; but I am, in an especial manner, bound to acknowledge my obligations to Lieut.-General Cuppage, to Major-General Millar, and to Colonel Sir A. Dickson, for the facilities which they afforded me, in permitting me to have access to the information contained in the several departments over which they respectively preside, with so much advantage to the public service. To Sir Alexander Dickson, in particular, I have to return my thanks for the support which I experienced from him, when very serious obstacles would otherwise have been thrown in my way,—to which support I was indeed indebted for the Master-General's permission to procure information, which had previously been refused to me, from the Royal Laboratory.

I am bound, also, to offer my best thanks to Colonel Sir Augustus Frazer, to Colonel Drummond, and Lieut.-Colonel Lloyd, and to Captains Scott and Barlow, for the several valuable papers which they freely allowed me to consult,—and to Major Charles C. Mitchell, for his kindness in designing the diagrams in the body of the work, and the vignette on the title page, the latter of which he engraved.

P.S.—I have been compelled to abandon the use of the diagrams above-mentioned, in consequence of a change in the arrangement of the work; and also of the vignette title-page, of which the plate is so much worn that it now affords only very faint impressions.

ADVERTISEMENT.

Third Edition.

It is now upwards of fifteen years, since, at the request of my professional friends, I compiled and published the first Edition of the 'British Gunner,' and, almost immediately after, retired, temporarily from the active duties of my profession.

On my return to England in 1836, my publisher informed me, that the second impression, a simple reprint of the first, was exhausted, and requested, as the work was still in demand, that I would prepare a third Edition for the press.

It was certainly satisfactory to find, that two unusually large impressions of a work like the 'British Gunner,' strictly professional, had been exhausted in less than eight years; but that circumstance alone would not have induced me to undertake the labor which my publishers request implied. I again appear as an author, in deference to the opinion of, I am afraid, over-partial friends.

The present Edition will, I trust, be found an improvement on its predecessor. It may be regarded as a new work in some respects. The arrangement has been partially changed, some of the articles abridged, others extended, all of them re-written, and a variety of new facts, and illustrations introduced.

I desire a second time to acknowledge the kind and cordial manner in which Lieut.-Colonel Dundas, and the other chiefs of the several departments in the Royal Arsenal granted me access to the records in their respective offices, and to add, that, should future Editions of the work be called for, it is very improbable that it will be again subjected to either addition or alteration.

Notes

EXPLANATORY OF THE SEVERAL SUBJECTS TO WHICH THEY RELATE.

CONSTRUCTION OF IRON GUNS.

If the reader will turn to either of the preceding Editions of this work, he will there find the following Note on the construction of iron ordnance.

> I had long been of opinion, that in the construction of iron ordnance much more metal was consumed than was at all necessary, and it had occurred to me that by a series of experiments we might arrive at the knowledge of a law by which guns might hereafter be constructed on better, and more scientific principles. I made a communication to that effect to the Master General, and his Grace referred it to the Select Committee at Woolwich for their examination and report. It was not, however, thought proper at the time to entertain my suggestion, but I have since had the satisfaction to see that some guns of much less thickness of metal have been cast, and I am confident it will eventually be admitted that hitherto we have proceeded on very erroneous principles.

The proposition to which the above Note has reference was laid before the Select Committee, which I attended, in 1827, and at that date the lightest iron gun in the Service of each of the undermentioned natures was,—

32-Pounders, 56 Cwts.
24 „ 48 „

And at the present time the lightest gun of each of those natures weighs,—

32-Pounders, 42 Cwts.
24 „ 37 „

It would thus appear, all the above guns being of the same length, that effect has been given, in part, to my suggestion. I will only further add that these guns of reduced weight and thickness of metal were introduced into the Service by the late Lieutenant General Millar, the then Inspector of Artillery, and that he was an active and zealous Member of the Committee who reported on my proposition.

PRACTICE VERSUS THEORY.

The practical Artillerist well understands the danger of trusting entirely to theory. It will perhaps be satisfactory to the uninitiated to have an opportunity of contrasting the following theoretical conclusions of Professor Babbage with the annexed practical results.

"If a gun," says the Professor, "is loaded with ball, it will not kick so much as when loaded with small shot; and amongst different kinds of shot, that which is the smallest, causes the greatest recoil against the shoulder. A gun loaded with a quantity of sand, equal in weight to a charge of snipe shot, kicks still more." Page 23, Economy of Machinery and Manufactures.

Memorandum of an Experiment made to ascertain the Recoils of a Musquet, suspended as a Pendulum Eprouvette, loaded with five drams and a half of powder, and the following charges.

Royal Arsenal, 20th March, 1838.

Lead Ball,	Weight 17 Drams $\frac{11}{16}$	....	Recoil	42·55	Degrees.
Bird Shot, Double B.	„	....	„	40·26	„
„ „ Number 2	„	....	„	42·63	„
„ „ „ 4	„	....	„	43·30	„
„ „ „ 6	„	....	„	42·54	„
„ „ „ 8	„	....	„	41·76	„
Dry loose sand	„	....	„	38·83	„

Note.—The results given above are each the average of three rounds, fired under precisely the same circumstances, and, in every instance, the charges of bird shot and sand were of exactly the same weight as the lead balls.

"If, in loading, a space is left between the wadding and the charge, the gun either recoils violently, or bursts." Idem.

Memorandum of an Experiment made to ascertain the Recoils of a Musquet, suspended in the place of a Gun Eprouvette, loaded with five drams and a half of powder, and the ball in contact with, and at certain distances from the charge.

NOTES.

Royal Arsenal, 7th April, 1837.

Ball in contact with the Charge				....	Recoil	44·73	Degrees.
6 inches from	„	„		....	„	37·36	„
12 „ „	„	„		...	„	35·83	„
18 „ „	„	„		....	„	32·70	„
24 „ „	„	„		....	„	29·56	„
30 „ „	„	„		....	„	26·43	„
36 „ „	„	„		....	„	24·0[illegible]	„
Without a Ball	„	„		....	„	16·43	„

Note.—The above results are likewise the averages of three rounds, and subsequently three additional rounds were fired from the same musquet, the ball, in these instances, being jammed into the Barrel, with paper, at the under-mentioned distances from the charge.

Ball 12 inches from the Charge....	Recoil	35·3	Degrees.
24 „ „ „ „	„	30·8	„
36 „ „ „ „	„	24·1	„

"If the muzzle of a gun has been accidentally stuck into the ground, so as to be stopped up with clay, or even with snow, or if it be fired with its muzzle plunged into water, the almost certain result is that it bursts." Idem.

Memorandum of an Experiment made, in 1835, to determine the Resisting Powers of a Musquet Barrel, under the conditions hereinafter stated.

The musket, loaded with six drams of powder and a lead ball, about five inches of the muzzle being stopped with moist sand, was fired without perceptible effect on the barrel. It was then re-loaded, with the same charge, the barrel being this time filled with sand, and again discharged without effect. Finally it was again loaded and fired with the muzzle plunged into a bank of sand with the same result.

An iron plug, two inches long, was next inserted into the muzzle of the barrel, and carefully secured in that situation by soldering. The breech was removed to admit the ball, wrapped in paper, and a charge of two drams of powder. It was then restored to its place, and the musquet again discharged without perceptible effect on the barrel. On examining the ball however it was found to have struck against the end of the plug, and that its surface was thereby somewhat flattened.

The experiment was then repeated, the charge of powder being increased to three drams, with the same result, except that, in this instance, the impression on the surface of the ball was less than in the former one; and on the charge being increased to four drams, such was the compression of the air, in front of the ball, that it never arrived at the plug,—the elastic fluid having in this, as in the two preceding experiments, escaped through the vent.

Finally the musquet was loaded with six drams of powder, and, on its being fired, so violent was the compression of the air that about two inches of the barrel immediately in contact with the plug gave way. On this occasion it was evident that the ball struck the plug subsequently to the bursting of the barrel, as it, in part, took the impression of the fracture.

WEIGHTS AND DIMENSIONS.

The reader will observe in the following pages, especially in the tables, that, in many instances, I have omitted to specify the particular weights, and dimensions employed. He will therefore have the goodness to bear in mind, in every such case, that the weights used are pounds, and decimals of a pound, and the dimensions feet and decimals of a foot.

MANŒUVRES OF FIELD ARTILLERY.

Lorsqu'on apprend aux troupes des choses inutiles, says Montècuculi, l'on n'a plus le tems de leur enseigner les nécessaires.

It is in accordance with this incontrovertible maxim, that I have selected, from the Authorized Codes, and inserted under the head "Exercise," only a portion of the Field Battery and Horse Artillery Manœuvres.

Certain individuals having of late ventured to dispute my father's claim to the original authorship of that system of Manœuvres which carried the Artillery through the late war, and Major General Drummond, the President of the Committee to whom the revision of the Field Battery Exercise was entrusted, having, on the completion of their labours, kindly sent me a manuscript copy of the revised Code, I presume I shall be excused, if I here insert, as my reply, the concluding paragraph of the Committee's Introduction.

"To the late Major Spearman, the Service is indebted for the first formation of a System of Exercise for Field Artillery. It was entitled "The Exercise of a Brigade of Guns," and consisted of Manœuvres adapted to six pieces. No attempt however has hitherto been made to form an entire code of instructions. Almost the whole of the present work therefore is new; and although every endeavour has been made, under these disadvantages, to render the work complete, yet no doubt there may be errors which future experience will correct."

THE

British Gunner.

AMMUNITION.—*Charge,—Cartridge.*

Ball-Cartridge Ammunition for an army on active service, is usually supplied and distributed on the following basis:—

Distribution.	*Infantry.*	*Cavalry.*
In the possession of the Soldier ..	60	30
With the Divisional Reserve	30	30
„ „ General „	50	„
In Action or Reserve....	140	60
In Depôt..	50	30
Total Rounds per Man	190	90

Vide also Field, Siege, and Garrison Artillery, for the proportion of Artillery Ammunition required to accompany an army in the field, to lay siege to a fortified place, or to defend one.

ANTIMONY,—*Composition.*

A metallic substance, brittle and crystaline, and of a silvery white appearance; very rarely found in a pure state in nature. As an ingredient in the composition of fire-works, it produces in the flame a whitish appearance, adds activity to the fire, and renders it clear, lively, and difficult to be extinguished.

Arms.—*Balls*,—*Cartridge*.

Weight, Dimensions, etc. of Small-Arms.

ARMS, ETC.	Calibre. In.	Length. Barrel.	Stock.	Bayonet.	Total.	Weight. Lbs.
FLINT LOCKS.						
Musquet ..*Regular Infantry*..	·753	3·500	4·838	1·417	6·250	11·281
Light ,,	·753	3·250	4·583	1·417	6·000	11·813
Carbine....*Heavy Cavalry*....	·753	2·167	3·417	1·250	4·667	8·906
Light ,,	·653			..	2·625	5 123
Rifle	·610	2·500	3·833	1·417	5·250	10·314
Pistol......*Heavy Cavalry*....	·753	·750		..		3·650
Light ,,	·610	·750		..		2·650
PERCUSSION LOCKS.						
Musquet ..*Infantry*..........	·753	3·250	4·542	1·458	6·000	11·172
Artillery	·733	2·500			5·297	9·792
Sappers	·733	2·500			6·000	10·000
Carbine....*Cavalry*	·733	3·167	3·521	..	3·521	7·688
Rifle ....*Belted Ball*	·704	2·500	3·854	1·771	5·625	11·188

FIRST GRAZES, OR POINT-BLANK RANGES.

Musquet..*Regular Infantry*............	169	yards.
Light	167	,,
Carbine ..*Heavy Cavalry*..............	149	,,
Light	123	,,
Rifle	175	,,
Pistol ....*Heavy Cavalry*..............	100	,,
Light	97	,,

Note.—The above arms, with flint locks, were severally fired, loaded with the Service Charges given in the General Table of Musquet, &c. Cartridges, over a horizontal plane, at the height of four feet, six inches from the ground. The Infantry Percussion Musquet, and the new Musquets for the Artillery and Sappers, are each sighted for a Point-Blank Range of 150 yards, as is also the new Cavalry Carbine. The Belted Ball Percussion Rifle is provided with two sights,—a Block Sight for 200, and a Leaf Sight for 300 yards.

ARTILLERY.—*Calibre,—Carriage,—Cartridge.*

The material is classed into Field, Siege, and Garrison Artillery.

Field Artillery.

The proportion of artillery necessary to accompany an army in the field depends on its strength, and the character of the troops composing it,—the face, features and general character of the country in which it is to act,—the state of the roads, and the means of transport,—the nature of the war, whether offensive or defensive, and the intended plan of operations.

If an army is to act on the offensive, in an open country having good roads and facility of transport, a larger proportion of artillery should accompany it, than it would be advisable to attach to the same army acting in a strong country, where the great object to be attained, is often, not to bring on a general action, but by marching, and manœuvering, to occupy advantageous positions; and where, consequently, celerity of movement is the point to be mainly considered. In hilly countries, this proportion must be still further reduced, and in mountainous countries the use of artillery should be altogether dispensed with unless it should be necessary to occupy an important post, to attack an intrenchment, or to dislodge the enemy from his position, by taking advantage of commanding eminences.

If, on the other hand, an army is to act upon the defensive, in a country having only tolerable roads, and where the probability of being obliged to undertake long and rapid marches is not great, a larger proportion of artillery, and a heavier description of battery should accompany it, than would be desirable with an army acting offensively in the same country.

But if this defensive system be carried on in a strong country, having no facility of transport, and where long and rapid marches may become indispensably necessary, not only should the proportion of artillery be reduced, but the batteries should likewise be composed of a lighter description of ordnance. It is obvious that in all these cases the great object to be attained is the adaptation of the artillery to the several circumstances above enumerated, and if this object be not constantly kept in view, it must result, either that the batteries will be inefficient, or that, instead of supporting the operations of the other troops, they will be the cause only of delay and embarrassment.

GENERAL PRINCIPLES APPLICABLE TO THE DISTRIBUTION OF FIELD ARTILLERY.

1. Field Artillery is assigned to, and combined with infantry and cavalry, formed into divisions, by active batteries, and by batteries of reserve.

Consequently—

2. The proportion of artillery necessary to place an army in the field on an efficient footing must depend, not alone on its strength, and the character of the troops composing it, but likewise on its composition and organization.

3. Experienced troops, or troops accustomed to act together, do not require so large a proportion of artillery for their support as inexperienced.

4. The relative proportion of artillery assigned to an army in the field, irrespective of its composition and organization, and of the composition, and calibre of the several batteries, varies, under ordinary circumstances, from one to three pieces of ordnance for each thousand men.

5. Artillery is, in general, assigned to cavalry in the proportion of two guns to one, as compared with that assigned to infantry; and, in forming the reserve of a corps-d'armée, this proportion is usually reversed.

Supposing therefore a division of infantry to consist of 9,000 men, and a division of cavalry of 3,000, and a corps-d'armée of three divisions of infantry and one of cavalry, such a corps, on the basis of 2 guns to 1,000 men, will require, to place it on an effective footing, 60 pieces of ordnance, or 10 batteries, distributed as follows:—

1st Division of Infantry	12	pieces of ordnance, or	2	batteries.
2nd " "	12	" "	2	"
3rd " "	12	" "	2	"
Cavalry Division	6	" "	1	"
Reserve	18	" "	3	"
Total	60	pieces of ordnance,	10	batteries.

It must here be observed that the practice of estimating the proportion of artillery to cavalry and infantry at so many pieces of ordnance per thousand men, is derived from the old system under which guns were assigned to particular regiments or battalions. It cannot therefore be considered, under present circumstances, as a rigorously accurate basis, although it is sufficiently so for all practical purposes.

CALIBRE OF THE ORDNANCE, AND RELATIVE PROPORTION OF HORSE TO FIELD ARTILLERY.

The calibre of the ordnance, and the relative proportion of horse to field artillery must depend on the composition of the army, and the nature of the country in which it is to act. As a general rule, 9-pounder batteries are considered the most eligible in an open country; in hilly countries, 6 and 3-pounder batteries; if a numerous cavalry is to act, the relative proportion of horse artillery must be increased, and, finally, if important positions are to be occupied, or strong redoubts or castles to be attacked, one or more 12 or 18-pounder batteries will be required.

BASIS ON WHICH THE SUPPLY OF ARTILLERY AMMUNITION FOR AN ARMY IN THE FIELD IS USUALLY CALCULATED.

Guns—18-Pounders		162	Rounds	per Gun.
12 „		178	„	„
9 „		163	„	„
6 „	(Heavy).	230	„	„
6 „	(Light).	220	„	„
3 „	(Heavy).	316	„	„
Howitzers—8-inch		112	Rounds	per Howitzer.
24-pounders		144	„	„
12 „		220	„	„

APPLICATION OF ARTILLERY IN THE FIELD.

The effect of artillery in the field is in direct proportion to the concentration of its fire. Field artillery has therefore for its object, not to strike down a few isolated men, and here and there to dismount a gun, but, by the combined and concentrated fire of powerful batteries, to open the enemy's ranks, to arrest his attacks, and to support those which may be directed against him.

Hence the following maxims:—

1. Ascertain what points of the enemy's position are to be attacked, and the effect expected from your fire.

Because until you are made acquainted with these particulars, it will be impossible for you to choose proper positions for your batteries, or to avoid placing your guns in situations which may be more advantageously occupied by the line.

2. Plant your guns, if possible, so as to obtain a cross fire, not only upon the enemy's position, but likewise upon the ground over which he must advance to attack you.

Batteries thus posted (figure 1), reciprocally defend each other. They represent the collateral flanks A B, A′ B′, of a front of fortification, the infantry B B′, in the interval between them, representing the curtain. In such situations, therefore, the angles formed by the lines of fire or defence B C, B′ C′, and the curtains or parts to be defended B B′, cannot be too open when acting on the offensive, or too acute when acting on the defensive, provided always, that in this last case the batteries themselves are defiladed.

3. Avoid positions in front or rear of your own line.

Guns thus posted, offer a two-fold object to the enemy's fire. Such, positions are, therefore, vicious in themselves. Besides that, in the former case, they will infallibly impede the manœuvres of your own troops, while, in the latter, they have a tendency to alarm and discourage them.

4. Do not, if you can possibly avoid it, disperse your batteries.

The flanks of the line to be defended (figure 1), are the proper positions for your guns. If, however, the line occupied by the troops be so extensive as to render such a disposition unavoidable, concentrate two or more of your most powerful batteries in a central position. Artillery, thus posted, may be regarded as a flat bastion, or redan, and if judiciously handled, it will be productive of corresponding effects.

5. Place your guns, as much as possible, under cover.

For this purpose, take advantage of banks, hedges, hollow ways, and other obstacles, both natural and artificial, which the vicinity may offer. Upon heights, the guns may be kept retired, so that their muzzles only are visible.

6. Avoid posting your batteries too soon; or if compelled, by circumstances, to do so, mask them until the moment they are to open their fire.

With this object in view, place your guns behind buildings, or any other cover which may offer, until their fire is to open. Where such obstacles do not present themselves, cover your batteries by other troops, particularly cavalry. Horse artillery may readily practise this manœuvre, by means of their mounted gun detachments.

7. Do not direct your fire on the enemy's artillery, unless your troops suffer more from his fire than his do from yours.

If compelled to fire on the enemy's artillery, do not attempt to oppose gun to gun, as by so doing, your success will, at best, be doubtful; but endeavour, by a powerful fire, concentrated on each of his batteries one after another, to crush them in succession.

8. Do not crowd your batteries into confined situations.

Guns thus posted, are not only fruitful in casualties, but they invite the enemy's attack. Your endeavour should, therefore be, so to post your batteries as to compel the enemy to divide his fire, while you retain the power of concentrating your own, at pleasure, upon any given point of his position.

9. Avoid positions which are exposed to the enemy's oblique or reverse fire.

This is the general rule, but, like other general rules, it is not without its exceptions; for instance, it will not apply, if such a position will enable you to produce a decisive effect upon the enemy before he can disable your guns.

10. Positions having a command of about 35 yards in 600, are to be preferred to more elevated ones.

If a position of greater command than this maxim supposes be occupied, the fire of your guns will be too plunging to do much execution; and further, it must be remembered that, in such situations, the danger to the enemy diminishes exactly in proportion as he advances to attack you. If it be absolutely necessary to occupy more commanding heights, secondary batteries must be so posted as to enfilade them at their bases.

11. Avoid posting your guns directly in front of your intended points of attack.

This maxim is founded upon the well-known axiom that the fire of field artillery should always be made to strike an object in the direction of its greatest dimensions; that is, it should be made to strike a line obliquely or in flank, a column in front.

12. Endeavour, especially at the commencement of an action, to deceive the enemy as to your real points of attack.

With this view, you should direct your fire, at the beginning of the action, generally over the enemy's whole line, or on those points which are most distant from your real object. It is only when your columns are ready to advance, that the fire of your batteries should be directed on the real points of attack, and then, every effort must be made to overwhelm and crush the enemy.

13. Be not too prodigal in employing your reserve.

If a particular point of your line requires additional support, or a favourable position is to be seized; if, having made an impression on your line, the enemy is preparing for a forward movement, or *vice versa*, a bold attack is to be made on his line, then is the time for the reserve to advance, and take part in the action.

14. Reserve a portion of your horse artillery for rapid and decisive operations.

If the enemy so concentrate the fire of his guns as to produce a decisive effect on your line, he must be instantly encountered at all hazards, by the rapid movement on his flank of your disposable batteries.

15. Never abandon your guns till the last extremity.

This, is the point of honour:—remember too that the last discharges are always the most destructive; that they may prove your salvation, or crown you with glory.

Composition of a Field, etc. Battery, Equipped for Foreign Service.

ORDNANCE, ETC.			BATTERIES.			OBSERVATIONS.
			Heavy.	Medium.	Light.	
ORDNANCE.						
Guns		18-Pounders ……	3	..	..	The Heavy, Colonial, and Mountain Batteries consist each of three Guns, and one Howitzer, and the Medium, and Light Batteries, Field & Horse Artillery, each of one Howitzer, and five Guns.
		12 „ ……	..	5	..	
		9 „ ……	..	5	..	
		6 „ (Heavy) ….	..	5	..	
		„ (Light)……	..	..	5	
		3 „ (Heavy) ….	..	..	5	
		„ (Medium) ..	..	..	3	
		„ (Light)……	..	..	3	
		1 „ (Ammuzette)	..	..	3	
Howitzers		8-Inch……..	1	..	..	Hy. or 18-Por. Batteries.
		$4\frac{2}{5}$ „ ……..	..	..	1	Col. and Mounn. Batteries.
		24-Pounder….	..	1	..	12, 9, & Hy. 6-Por. Batteries
		12 „ ….	..	..	1	Lt. 6 & Hy. 3-Por. Batteries
CARRIAGES.						
Gun Carriages …………			3	5	5	The Colonial and Mountain Service Batteries have no Spare Carriages.
		(Spare) ….	1	1	1	
Howitzer „ …………			1	1	1	
Ammunition	Waggons	Gun …………	3	5	5	The 12-Por. Batteries have each five reserve Waggons The 9-Por. Batts. two, and the 6-Por. Batts. one, each
		Reserve ……	6	5	..	
		Howitzer …. …	1	1	1	
		Reserve..	3	1	1	
	Cars	Gun …………	..	..	3	The Ammunition for Mountain Service Batteries is packed in Boxes, and carried on the backs of Mules.
		Reserve ……	..	..	3	
		Howitzer ……..	..	..	1	
		Reserve..	..	..	1	
Platform Waggons ……..			1	..	..	
Store Carts ……………			1	1	1	
„ Waggons…………			2	1	1	The 12-Por. Battery has one Waggon additional.
Forge „ …………			1	1	1	
Forges (Mule Carriage)….			..	..	1	Mountain Service Batteries

Personnel of a Field etc. Battery, Equipped for Foreign Service.

PERSONNEL, ETC.	BATTERIES.											
	H. Artillery.				F. Artillery.				M.&C. Service.			
	12-Pounder.	9-Pounder.	6-Pounder.	3-Pounder.	18-Pounder.	12-Pounder.	9-Pounder.	6-Por. Light.	3-Por. Med.	3-Por. Light.	3-Por. Light.	1-Pounder.
Gunners, etc.												
Captains	2	2	2	2	2	2	2	2	..	..	..	..
Lieutenants	3	3	3	3	3	3	3	3	1	1	1	1
Surgeons	1	1	1	1	1	1	1	1	..	..	..	..
Staff-Serjeants	2	2	2	2	..	..	..	..	..	..	..	..
Serjeants	3	3	3	3	3	3	3	3	1	1	1	1
Corporals	3	3	3	3	3	3	3	3	1	2	2	1
Bombardiers	8	7	6	6	6	6	6	6	2	2	2	2
Buglers	..	..	..	..	2	2	2	2	..	..	..	..
Gunners	96	90	80	80	90	90	90	80	20	25	21	20
Total	118	111	100	100	110	110	110	100	25	31	27	25
Drivers, etc.												
Staff-Serjeants	..	..	..	..	1	1	1	1	..	..	..	..
Serjeants	..	..	..	..	2	2	2	2	..	1	1	..
Corporals	..	..	..	..	6	6	5	4	1	1	1	1
Trumpeters	1	1	1	1	1	1	1	1	..	..	..	..
Farriers	1	1	1	1	1	1	1	1	..	..	..	..
Shoeing Smiths	5	4	3	3	4	4	4	3	1	1	1	1
Carriage ,,	1	1	1	1	1	1	1	1	..	..	..	..
Collar-Makers	2	2	2	2	2	2	2	2	..	..	..	..
Wheelers	2	2	1	1	2	2	2	2	..	..	..	..
Drivers	93	80	69	65	100	97	82	71	14	20	19	11
Total	105	91	78	74	120	117	101	88	16	23	22	13
Horses.												
Draft	146	122	104	98	152	146	122	104	24	..	..	18
,, Spare	14	13	11	10	18	18	15	13	2	..	..	2
Riding	72	71	58	58	20	20	19	18	..	..	..	..
,, Spare	7	7	6	6	..	..	..	..	..	..	..	..
Baggage	7	7	7	7	7	7	7	7	..	..	..	..
Total	246	220	186	179	197	191	163	142	26	..	..	20
Mules.												
Draft	..	..	..	..	..	..	..	..	..	..	24	..
,, Spare	..	..	..	..	..	..	..	..	..	..	5	..
Pack	..	..	..	..	..	..	..	..	..	24	..	..
,, Spare	..	..	..	..	..	..	..	..	..	6	..	..
Riding	..	..	..	..	..	..	..	..	..	4	4	..
Baggage	..	..	..	..	..	..	..	..	..	1	1	..
Total	..	..	..	..	..	..	..	..	..	35	34	..

Detail of a Proportion of Ammunition for a Field Battery, or Battery of Horse Artillery of Each Nature.

AMMUNITION, ETC.				BATTERIES.					
				18-Pounder.	12-Pounder.	9-Pounder.	6-Por. Heavy.	6-Por. Light.	3-Por. Heavy.
Shot	Round			342	570	570	870	855	1360
	Case	Common		36	82	107	122	112	232
		Spherical		160	322	222	242	261	116
Shells, Common, empty				48	56	56	56	84	84
Carcases, Fixed				12	4	4	4	8	8
Cartridges	Filled	Charges	6℔ 0 oz.	378	..	..	..	..	..
			4 ,, 8 ,,	108	..	..	..	..	..
			4 ,, 0 ,,	112	890	..	..	..	..
			3 ,, 0 ,,	..	..	815	..	..	..
			2 ,, 8 ,,	..	144	144	144	..	..
			2 ,, 0 ,,	..	..	..	1150	.	..
			1 ,, 8 ,,	..	..	..	..	1100	..
			1 ,, 4 ,,	..	..	..	..	220	220
			1 ,, 0 ,,	..	..	..	..	..	1580
		Bursters	1 ,, 14 ,,	48	..	..	..	..	..
			0 ,, 15 ,,	52	..	..	..	..	..
			0 ,, 10 ,,	..	56	56	56	..	..
			0 ,, 6 ,,	..	72	72	72	..	..
			0 ,, 5 ,,	108	..	..	..	84	84
			0 ,, 4½ ,,	..	250	..	..	116	116
			0 ,, 3½ ,,	..	..	150	..	..	..
			0 ,, 2½ ,,	..	..	..	170	145	..
	Empty			650	900	750	700	700	650
Tubes, Brass				2100	1800	1500	2000	2000	2300
Portfires				156	216	180	204	204	216
Fuzes	Spherical	Cut	·4	160	322	222	242	261	116
			·6	160	322	222	242	261	116
			·8	160	322	222	242	261	116
		Uncut		160	322	222	242	261	116
	Common, Graduated			60	70	70	70	105	105
Quick-match, Clues, 10 yards in each				13	12	9	8	8	7
Slow-match			skeins	26	30	24	22	22	20

Distribution of Ammunition in the Limber and Waggon Boxes of Field Guns and Howitzers.

DISTRIBUTION, ETC.	AMMUNITION.						
	Round Shot.	Case-Shot		Carcases.	Cartridges		Bursters.
		Common.	Spherical.		Filled.	Empty.	
18-Pounder Gun.							
Waggon Limber Near Box......	3	3	6	..	12	..	6
Waggon Limber Off ,, ...	9	3	..	..	12	..	..
Waggon Body Fore Box	9	..	6	..	15	..	6
Waggon Body Hind ,, ...	15	..	..	..	15	50	..
In Action....	36	6	12	..	54	50	12
Reserve 1st Waggon..	36	6	12	..	54	50	12
Reserve 2nd ,, ..	42	..	12	..	54	50	12
Total per Gun..	114	12	36	..	162	150	36
12-Pounder Gun.							
Gun Limber Near Box..........	3	3	..	..	6	..	..
Gun Limber Middle ,, ...	..	..	6	..	6	..	6
Gun Limber Off ,, ...	3	3	..	..	6	..	..
Waggon Limber Near Box	6	..	10	..	16	..	10
Waggon Limber Off ,, ...	12	4	..	..	16	..	..
Waggon Body Fore Box	12	..	12	..	24	50	12
Waggon Body Hind ,, ...	24	..	..	..	24	50	..
In Action....	60	10	28	..	98	100	28
Reserve ..	54	4	22	..	80	50	22
Total per Gun..	114	14	50	..	178	150	50
9-Pounder Gun.							
Gun Limber Near Box..........	8	4	4	..	16	..	4
Gun Limber Off ,, ...	8	4	4	..	16	..	4
Waggon Limber Near Box......	8	4	4	..	16	50	4
Waggon Limber Off ,, ...	8	4	4	..	16	..	4
Waggon Body Fore Box...	22	..	8	..	34	..	8
Waggon Body Hind ,, ...	32	..	..	..	28	50	..
In Action....	86	16	24	..	126	100	24
Reserve ..	28	3	6	..	37	20	6
Total per Gun..	114	19	30	..	163	120	30

DISTRIBUTION of AMMUNITION—*continued.*

DISTRIBUTION, ETC.	AMMUNITION.						
	Round Shot.	Case-Shot		Carcases.	Cartridges		Bursters.
		Common.	Spherical.		Filled.	Empty.	
6-POUNDER GUN. (Heavy)							
Gun Limber Near Box	10	5	10	..	25	..	10
Gun Limber Off ,,	20	5	..	..	25	..	..
Waggon Limber Near Box	10	5	10	..	25	80	10
Waggon Limber Off ,,	20	5	..	..	25	..	..
Waggon Body Fore Box	35	..	10	..	45	..	10
Waggon Body Hind	55	..	..	..	55	20	..
In Action	150	20	30	..	200	100	30
Reserve	24	2	4	..	30	10	4
Total per Gun	174	22	34	..	230	110	34
6-POUNDER GUN. (Light)							
Gun Axletree Box	3	3	..	..	..	..	..
Gun Limber Near Box	8	4	8	..	22	..	8
Gun Limber Off ,,	16	4	..	..	24	..	..
Waggon Limber Near Box	12	4	8	..	23	..	8
Waggon Limber Off ,,	20	4	..	..	25	..	..
Waggon Body Fore Box	35	..	10	..	55	..	10
Waggon Body Hind ,,	55	..	..	..	45	100	..
In Action	149	19	26	..	194	100	26
Reserve	22	1	3	..	26	10	3
Total per Gun	171	20	29	..	220	110	29
3-POUNDER GUN. (Heavy)							
Gun Axletree Box	4	4	..	..	..	..	..
Gun Limber Near Box	30	10	..	..	40	..	..
Gun Limber Off ,,	20	10	..	..	38	..	..
Waggon Limber Near Box	30	10	..	..	40	..	..
Waggon Limber Off ,,	20	10	..	..	30	..	..
Waggon Body Fore Box	84	..	..	..	84	..	..
Waggon Body Hind ,,	84	..	..	..	84	100	..
Total per Gun	272	44	..	..	316	100	..

DISTRIBUTION OF AMMUNITION—*continued.*

DISTRIBUTION, ETC.	AMMUNITION.						
		Case-Shot			Cartridges		
	Round Shot.	Common.	Spherical.	Carcases.	Filled.	Empty.	Bursters.
3-POUNDER GUN. (Medium)							
Gun Limber Box	21	9	..	..	30		..
Car Fore Box	21	9	..	..	30		..
Car Hind „	30	..	..	..	30		..
In Action	72	18	..	..	90		..
Reserve Car Fore Box	21	9	..	..	30		..
Reserve Car Hind „	30	..	..	..	30		..
Total per Gun	123	27	..	..	150		..
3-POUNDER GUN. (Light)							
Draft Mules Leader Near Box	10	2	..	..	12		..
Draft Mules Leader Off „	10	2	..	..	12		..
Draft Mules Shaft Near Box	10	2	..	..	12		..
Draft Mules Shaft Off „	10	2	..	..	12		..
Pack Mule	51	9	..	..	60		..
In Action	91	17	..	..	108		..
Reserve Mule	51	9	..	..	60		..
Total per Gun	142	26	..	..	168		..
3-POUNDER GUN. (Light)							
Pack Mules 1st Mule Near Box	30	..	..	..	30		..
Pack Mules 1st Mule Off „	21	9	..	..	30		..
Pack Mules 2nd Mule Near Box	30	..	..	..	30		..
Pack Mules 2nd Mule Off „	21	9	..	..	30		..
Total per Gun	102	18	..	..	120		..
1-POUNDER GUN. (Ammuzette)							
Gun Limber Box	40	15	..	..	55		..
Car Fore Box	55	..	..	..	55		..
Car Hind „	55	..	..	..	55		..
Total per Gun	150	15	..	..	165		..

DISTRIBUTION of AMMUNITION—*continued.*

DISTRIBUTION, ETC.	AMMUNITION.						
		Case-Shot			Cartridges		
	Shells.	Common.	Spherical.	Carcases.	Filled.	Empty.	Bursters.
8-INCH HOWITZER.							
Waggon Limber Near Box	..	..	6	..	6	..	6
Waggon Limber Off „	6	..	..	..	6	..	6
Waggon Body Fore Box	..	..	7	1	8	..	7
Waggon Body Hind „	6	..	..	2	8	50	6
In Action	12	..	13	3	28	50	25
Reserve 1st Waggon	12	..	13	3	28	50	25
Reserve 2nd „	12	..	13	3	28	50	25
Reserve 3rd „	12	..	13	3	28	50	25
Total per Howitzer	48	..	52	12	112	200	100
24-POUNDER HOWITZER.							
Howitzer Limber Near Box	..	..	12	..	12	50	12
Howitzer Limber Off „	8	4	..	..	12	..	8
Waggon Limber Near Box	..	..	12	..	12	..	12
Waggon Limber Off „	8	4	..	..	12	..	8
Waggon Body Fore Box	..	..	18	..	18	..	18
Waggon Body Hind „	16	..	..	2	18	50	16
In Action	32	8	42	2	84	100	74
Reserve	24	4	30	2	60	50	54
Total per Howitzer	56	12	72	4	144	150	128
12-POUNDER HOWITZER.							
Howitzer Limber Near Box	..	..	18	..	18	..	18
Howitzer Limber Off „	12	4	..	..	16	..	12
Waggon Limber Near Box	..	..	18	..	18	..	18
Waggon Limber Off „	12	4	..	..	16	..	12
Waggon Body Fore Box	..	..	32	..	32	..	32
Waggon Body Hind „	24	..	..	4	28	100	24
In Action	48	8	68	4	126	100	116
Reserve	36	4	48	4	92	50	84
Total per Howitzer	84	12	116	8	220	150	200

IBUTION OF AMMUNITION—*continued.*

ISTRIBUTION, ETC.	AMMUNITION.						
		Case-Shot			Cartridges		
	Shells.	Common.	Spherical.	Carcases.	Filled.	Empty.	Bursters.
CH HOWITZER. (Colonial.)							
er Limber Box............	12	4			16		12
Car Fore Box............	12	4			16		12
Car Hind ,, ...	16	..			16		16
In Action..	40	8			48		40
Reserve Car Fore Box..	12	4			16		12
Reserve Car Hind ,, ..	16	..			16		16
Total per Howitzer..	68	12			80		68
CH HOWITZER. (Mountain.)							
ules Leader Near Box ..	6	..			6		6
ules Leader Off ,, ..	4	2			6		4
ules Shaft Near Box ..	6	..			6		6
ules Shaft Off ,, ..	4	2			6		4
Pack Mule Near Box ..	12	..			12		12
Pack Mule Off ,, ..	8	4			12		8
In Action..	40	8			48		40
rve 1st Mule Near Box..	12	..			12		12
rve 1st Mule Off ,, ..	8	4			12		8
rve 2nd Mule............	20	4			24		20
Total per Howitzer..	80	16			96		80
HOWITZER. (Mountain.)							
ules 1st Mule Near Box	12	..			12		12
ules 1st Mule Off ,,	8	4			12		8
ules 2nd Mule Near Box	12	..			12		12
ules 2nd Mule Off ,,	8	4			12		8
In Action..	40	8			48		40
Reserve Mule Near Box..	12	..			12		12
Reserve Mule Off ,, ..	8	4			12		8
Total per Howitzer..	60	12			72		60

Implements and **Stores** for a Field Battery, or Battery of Horse Artillery, of each Nature, equipped for Foreign Service.

STORES, ETC.	BATTERIES.			OBSERVATIONS.
	Heavy.	Medium.	Light.	
IMPLEMENTS, ETC.				*With each Piece of Ordnance.*
Spunges	3	3	3	Including 1 spare per Howitzer.
,, Heads	1	1	1	Spare.
Wadhooks	1	1	1	With Guns only.
Rammer-Heads	1	1	1	Spare.
Priming-Irons....sets	1	1	1	
Vent-Punches	1	1	1	
Claw-Hammers	1	1	1	
Spikes, Spring	2	2	2	
,, Common	2	2	2	
Fuze-Boxes, White ·4.	..	1	1	3-Pounder Guns, none.
,, ,, Blue ·6.	..	1	1	,, ,,
,, ,, Black ·8.	..	1	1	,, ,,
,, Augers	..	1	1	,, ,,
Compasses......pairs	..	1	1	,, ,,
Rules, Box	..	1	1	,, ,,
Knives and Saws	..	1	1	,, ,,
Files, 3-square	..	1	1	,, ,,
Rasps, ½-round	..	1	1	,, ,,
Mallets	..	1	1	,, ,,
Setters	..	2	2	,, ,,
Pincers (Iron) ..pairs	..	1	1	,, ,,
Cork-screws	..	1	1	,, ,,
Funnels (Tin)	..	1	1	,, ,,
Scrapers, Shell	..	1	1	,, ,,
Thumbstalls	..	2	2	
Tube-Pockets	..	1	1	
Powder-Horns	2	..	..	
Lintstocks	2	..	..	
Portfire-Sticks	..	2	2	
,, Cutters	1	1	1	
Gun-Locks	1	1	1	
Quadrants	1	..	..	
Perpendiculars	1	..	..	
Tools: Felling Axes	2	1	1	Intrenching.
Tools: Pickaxes	2	1	1	,,
Tools: Hand-Bills	2	1	1	,,
Tools: Spades	4	2	2	,,
Grease Boxes	1	1	1	

Implements and Stores—*continued.*

STORES, ETC.	Batteries.			Observations.
	Heavy.	Medium	Light.	
Implements, etc.				*With each Piece of Ordnance.*
Linchpins	1	1	1	Spare.
Washers	1	1	1	,,
Jacks, Hand-Screw ..	1	..	..	Guns only.
,, Lifting........	1	1	1	
Marline ....skeins	2	2	1	
Hambro' Line.. ,,	1	1	1	
Handspikes, Common	4	..	..	With guns only.
,, Traversing	2	2	2	Heavy Battery, Howitzers only.
Box-Covers, Limber..	..	2	2	Painted or dyed Canvas.
Water Buckets	2	1	1	Leather, 8-in. Howitzers, 1 only.
Reaping Hooks	..	..	..	1 for every 2 Horses.
Harness, Men's......	2	1	1	With 4 bands.
,, Horse's	..	..	..	Vide Harness.
Prolonge............	2	..	..	
Implements, etc.				*With each Ammunition Waggon.*
Hambro' Line..skeins	1	1	1	
Marline........ ,,	2	2	2	
Fuze-Boxes, White ·4 .	1	1	1	3-Pounder Gun, none.
,, ,, Blue ·6..	1	1	1	,, ,,
,, ,, Black ·8..	1	1	1	,, ,,
,, Augers	1	1	1	,, ,,
Compasses......pairs	1	..	..	,, ,,
Rules, Box	1	..	..	,, ,,
Knives and Saws	1	1	1	,, ,,
Files, 3-square	1	1	1	,, ,,
Rasps, ½-round	1	..	..	,, ,,
Mallets	1	1	1	,, ,,
Setters	2	2	2	,, ,,
Pincers (Iron)....pairs	1	..	..	,, ,,
Corkscrews..........	1	1	1	,, ,,
Funnels (Tin)	1	1	1	,, ,,
Scrapers, Shell	1	1	1	,, ,,
Tube-pockets........	1	1	1	
Portfire-Sticks	2	2	2	Of Guns, only with 18-pounders.
Scissors ....pairs	1	1	1	
Grease Boxes........	1	1	1	
Linchpins	1	1	1	Spare.
Washers	1	1	1	,,

IMPLEMENTS AND STORES—*continued.*

STORES, ETC.	BATTERIES. Heavy.	BATTERIES. Medium.	BATTERIES. Light.	OBSERVATIONS.
IMPLEMENTS, ETC.				*With each Ammunition Waggon.*
Thumbstalls	2	2	2	
Picket Rope, 3-in..yds.	25	25	25	
Camp Pickets........	4	4	4	
Wood Mauls	2	2	2	
Tools { Felling Axes.	1	1	1	Intrenching.
Pickaxes	1	1	1	,, ,,
Hand-Bills..	1	1	1	,, ,,
Spades....;	2	2	2	,, ,,
Box-Covers, Limber..	2	2	2	Painted or dyed canvas.
,, Waggon..	2	2	2	,, ,, ,,
Water Buckets........	1	1	1	Leather.
Reaping Hooks.......	..	..	..	1 for every 2 Horses.
Rope, 2-inch....pieces	2	2	2	Each piece of five yards.
Horse-Shoes......sets	40	40	40	3 sets of Nails to each.
Harness, Horse......	..	..	..	Vide Harness.
IMPLEMENTS, ETC.				*With each Spare Gun Carriage.*
Grease Boxes........	1	1	1	
Linchpins	1	1	1	Spare.
Washers	1	1	1	,,
Tools { Felling Axes.	1	1	1	Intrenching.
Pickaxes	1	1	1	,,
Hand Bills ..	1	1	1	,,
Spades	2	2	2	,,
Box-Covers, Limber..	1	1	1	Painted or dyed canvas.
Wheels, Heavy	1	1	..	
,, Limber......	1	..	..	
,, Light	3	2	3	
Axletrees, Whole	1	1	..	Heavy.
,, Arms... ..	2	2	2	Light.
Shafts, Complete......	2	2	2	
Pintails	1	1	..	18 and 12-Pounder Batt. only.
Limber-Hooks........	1	1	1	
Driving-Bolts........	1	1	1	
Perches	1	1	1	
Nose-Plates..........	1	1	1	
Trail-Plate Eyes	1	1	1	
Side-Arm Staples	..	20	20	
Elevating Screws	1	1	1	

Implements and Stores—*continued.*

STORES, ETC.	BATTERIES.			OBSERVATIONS.
	Heavy.	Medium.	Light.	
IMPLEMENTS, ETC.				*With each Spare Gun Carriage.*
Water Buckets........	1	1	1	Leather.
Reaping Hooks........	..	..	..	1 for every 2 Horses.
Linchpins, Heavy	4	6	..	
,, Light	10	10	8	
Gyn, Blocks, etc......	1	..	..	Complete with Sling and Fall.
Handspikes, Common..	16	..	..	For the Guns only.
,, Traversing	2	2	2	
Wheeler's Tools....sets	1	1	1	Vide Artificer's Tools.
Harness, Horse	..	..	..	,, Harness.
STORES, ETC.				*With each Platform Waggon.*
Grease Boxes,.........	1	..	..	
Linchpins	1	..	..	Spare.
Washers	1	..	..	,,
Water Buckets	1	..	..	Leather.
Reaping Hooks	..	..	..	1 for every 2 Horses.
Harness, Horse.......	..	..	..	Vide Harness.
STORES, ETC.				*With each Store Cart.*
Grease Boxes.........	1	1	1	
Linchpins	1	1	1	Spare.
Washers	1	1	1	,,
Water Buckets........	1	1	1	Leather.
Reaping Hooks	..	..	..	1 for every 2 Horses.
Harness, Horse.......	..	..	..	Vide Harness.
IMPLEMENTS, ETC.				*With each Store Waggon.*
Grease Boxes.........	1	1	1	
Linchpins............	1	1	1	Spare.
Washers	1	1	1	,,
Box-Covers, Limber...	1	1	1	Painted or dyed Canvas.
Rope, 3-inch.....yards	25	25	25	Tarred.
,, Lashing ... ,,	226	113	25	9 and 6-Por. Batt. 25 yards only.
Horse Shoes.......sets	40	40	40	3 sets of Nails to each.
Steel, Sheer ....lbs.	28	28	28	
,, Blister...... ,,	28	28	28	
Dark Lanterns........	3	3	3	

IMPLEMENTS AND STORES—*continued.*

STORES, ETC.	BATTERIES. Heavy.	BATTERIES. Medium.	BATTERIES. Light.	OBSERVATIONS.
STORES, ETC.				***With each Store Waggon.***
Candles..........lbs.	12	12	12	
Scythes..............	6	6	6	
Ragstones	..	..	..	1 for every Scythe.
Water Buckets	6	6	6	Leather, Spare.
Nose Bags	..	..	..	1-10th the No. of Horses, Spare.
Forage Cords .....sets	6	6	6	Spare.
Reaping Hooks	6	6	6	,,
Iron Flat......lbs.	56	56	56	
Square.... ,,	28	28	28	
Rod ...... ,,	28	28	28	
Round.... ,,	28	28	28	
Hooping .. ,,	28	28	28	
Wheels, Heavy	..	1	..	Spare.
,, Light........	1	..	1	,,
Fellies	12	9	9	In the rough,—Assorted.
Spokes	24	18	18	,, ,,
Splinter Bars	1	1	1	,, ,,
Streaks	9	6	6	Assorted.
Grease ....kegs	8	8	8	
Copper Measures. .sets	2	1	1	From ¼ to 4 lbs. each.
Steelyard and Weight..	1	1	1	Forage, to weigh 200 lbs.
Hides Black Heavy	1	1	1	
Light.	1	1	1	
White, Horse.	1	1	1	
Bazils, Black ....doz.	3	3	2	
,, Brown.... ,,	3	3	2	
Wax, Black ....lbs.	4	4	4	
,, Bees' .... ,,	2	2	2	
Thread, Collar.... ,,	6	6	4	
,, Hemp.... ,,	10	10	8	
Bristles ....ozs.	8	8	6	
Whips, Short.........	6	6	6	
Whipcord ....lbs.	2	2	2	
Does' Hair.......... ,,	28	28	28	
Buckles 2-Inch. doz.	2	2	2	
1¾ ,, ,,	3	3	3	
1½ ,, ,,	3	3	3	
1 ,, ,,	3	3	3	
¾ ,, ,,	3	3	3	
Serge ....yards	20	20	20	

IMPLEMENTS AND STORES—*continued.*

STORES, ETC.			BATTERIES.			OBSERVATIONS.
			Heavy.	Medium.	Light.	
STORES, ETC.						*With each Spare Waggon.*
Girthweb ....yards			20	20	20	
Brushes, Hard			12	12	12	
Oil, Sweet......quarts			1	1	1	
„ Neat........galls.			10	10	8	
Side-Arm Straps			..	6	6	
Screws ....doz.			8	8	8	Assorted.
Nails	Streak		100	100	100	
	Clasp	40 py.	200	..	..	
		30 „	300	..	..	
		20 „	300	300	300	
		10 „	600	600	600	
		6 „	600	600	600	
	Clout	6 py.	600	600	600	The larger sort Chisel-pointed.
		4 „	600	600	600	„ „
		3 „	600	600	600	„ „
		2 „	600	600	600	„ „
	Tacks		1500	1000	1000	Assorted.
Water Buckets			1	1	1	Leather.
Reaping Hooks			..	..	..	1 for every 2 Horses.
Collarmaker's tools, sets			1	1	1	Vide Artificer's Tools.
Harness, Horse			..	..	..	„ Harness.
IMPLEMENTS, ETC.						*With each Forge Waggon.*
Grease Boxes.........			1	1	1	
Linchpins............			1	1	1	Spare.
Washers			1	1	1	„
Tools	Felling Axes.		1	1	1	Intrenching
	Pickaxes		1	1	1	„
	Hand-Bills..		1	1	1	„
	Spades		2	2	2	„
Box-Covers, Limber...			1	1	1	Painted or dyed Canvas.
Anvils with Blocks....			1	1	1	
Bellows ....pairs			1	1	1	
Coals ....bush.			2	2	2	
Water Buckets........			1	1	1	Leather.
Reaping Hooks			..	..	..	1 for every 2 Horses.
Carriage Smith's tools..			1	1	1	Vide Artificer's Tools.
Shoeing „ „ ..			..	..	..	1 set for each Smith.
Harness, Horse.......			..	..	..	Vide Harness.

FURTHER Proportions of IMPLEMENTS and STORES for Six Months' Consumption of a Field Battery, or Battery of Horse Artillery, already Equipped.

STORES, ETC.	BATTERIES.			OBSERVATIONS.
	Heavy.	Medium.	Light.	
GENERAL STORES.				
Gyn, Blocks, etc......	1	..	..	Complete, with Sling and Fall.
Rope, 2-Inch......coils	1	1	1	Tarred.
,, Lashing.... ,,	1	1	1	
Spunyarn......... ,,	1	1	1	
Claw-Hammers	2	2	2	
Tools { Felling Axes.	3	3	3	Intrenching.
{ Pickaxes ...	3	3	3	,,
{ Hand-Bills..	3	3	3	,,
{ Spades	6	6	6	,,
Grease .... kegs	20	16	16	
Harness, Wheel	2	2	2	Vide Harness.
,, Leader......	8	4	4	,, ,,
Saddles	2	2	2	Riding,—Spare.
Bridles...............	2	2	2	,, ,,
Whips	5	3	3	Short.
Leggins..............	5	3	3	,,
Headstalls	10	6	6	With chain Reins.
Hames (Iron)	4	3	2	Spare.
Nose-Bags	..	..	..	Canvas ;—¼ No. of Horses.
Corn-Bags(2 days' corn)	..	..	..	1-6th spare per mounted man.
,, Sacks	..	..	..	1 ,, ,, carriage.
Forage Cords .....sets	..	..	..	1 for 2 Drivers.
Spikes, Spring.........	2	2	2	
,, Common.......	2	2	2	
Priming-Irons ...sets	2	2	2	
Park-Pickets	60	50	44	
Wood-Mauls	6	6	6	
Lanterns, Muscovy ...	4	2	2	
,, Dark	4	2	2	
Candles ....lbs.	36	36	36	
Water Buckets	50	50	40	Leather.
Wadmiltilts	1	1	1	
Hair Cloths	1	1	1	
Tarpaulins	1	1	1	For covering Ammunition.
Scales and Beams	1	1	1	
Weights	1	1	1	4 lb. piles.
Turpentine......galls.	1	1	1	
Paint ....lbs.	56	56	56	Lead Color.

RTHER IMPLEMENTS AND STORES—*continued.*

STORES, ETC.	BATTERIES. Heavy.	Medium.	Light.	OBSERVATIONS.
ENERAL STORES.				
ıseed Oil.. ...galls.	6	6	6	
int Brushes........	6	6	6	Large and Small of each.
le-Arm Straps......	18	18	18	
ankets	..	..	..	¼ No. of men Spare.
nteens	..	..	..	,, ,, ,,
ıvre Sacks..........	..	..	..	,, ,, ,,
HEELER'S STORES.				
llies ..(in the rough)	..	..	..	Accordingtolocalityofoperations
okes ,, ,,	..	..	..	,, ,, ,,
linter Bars ,, ,,	..	..	..	,, ,, ,,
ıafts ,, ,,	..	..	..	,, ,, ,,
ıides, Fore ,, ,,	..	..	..	,, ,, ,,
,, Hind ,,	..	..	..	,, ,, ,,
nderpoles ,, ,,	..	..	..	,, ,, ,,
rches ,, ,,	..	..	..	,, ,, ,,
afts, complete	..	..	..	,, ,, ,,
Gun Light.	4	..	..	,, ,, ,,
Heavy	..	..	..	,, ,, ,,
heels Limber	..	..	..	,, ,, ,,
Wag. Fore.	..	..	..	,, ,, ,,
Hind	..	..	..	,, ,, ,,
on-Axles	..	..	..	,, ,, ,,
·ow Bars	..	..	..	
andspikes, Common..	20	..	..	Short.
,, Traversing	..	6	6	
rews	50	25	25	Assorted.
Streak	2000	2000	2000	
Clasp 40 py.	500	..	..	
30 ,,	500	..	..	
20 ,,	1000	1000	1000	
10 ,,	3000	2000	1000	
ails 6 ,,	2000	2000	1000	
Clout 6 py.	2000	2000	2000	The largest size Chisel-pointed.
4 ,,	2000	2000	2000	,, ,, ,,
3 ,,	2000	2000	2000	,, ,, ,,
2 ,,	2000	2000	2000	,, ,, ,,
Tacks........	5000	4000	3000	Assorted.
'heeler's Tools ...sets	1	1	1	Spare.

FURTHER IMPLEMENTS AND STORES—*continued.*

STORES, ETC.	BATTERIES.			OBSERVATIONS.
	Heavy.	Medium.	Light.	
SMITH'S STORES, ETC.				
Coals ....bush.	27	27	27	
Horse Shoes	..	..	..	6 sets per Horse.
Nails	..	..	..	3 ,, ,, set of Shoes.
Iron Flat 1½-Inch ....lbs.	56	56	56	
Square.......... ,,	56	56	56	
Round .... ,,	56	56	56	
Rod .... ,,	56	56	56	
Hooping........ ,,	56	56	56	
Steel, Sheer .... ,,	28	28	28	
,, Blister .... ,,	28	28	28	
Carriage Smith's Tools..sets	1	1	1	Vide Artificer's Tools.
Shoeing ,, ,, ,,	..	..	..	1 set for each Smith.
COLLAR MAKER'S STORES.				
Bristles................ozs.	24	24	18	
Whipcord ....lbs.	6	6	6	
Does' Hair .... ,,	86	86	86	
Serge ....yds.	60	60	60	
Hides Black Heavy....	3	3	3	
Light......	3	3	3	
White, Horse......	3	3	3	
Bazils, Black ....doz.	9	9	6	
,, Brown.......... ,,	9	9	6	
Wax, Black ....lbs.	6	6	6	
,, Bees' .... ,,	6	6	6	
Thread Collar .... ,,	18	18	12	
,, Hemp .... ,,	30	30	24	
,, Whited Brown.. ,,	2	2	2	
Brushes, Hard .... sets	36	36	36	
,, Soft				
,, Water				
Oil, Sweet ....galls.	1	1	1	
,, Neat .... ,,	30	30	24	
Buckles 2-Inch ......doz.	9	9	9	
1¾ ,, ... ,,	9	9	9	
1½ ,, ... ,,	9	9	9	
1 ,, ... ,,	9	9	9	
¾ ,, ... ,,	9	9	9	
Collar-Maker's Tools....sets	1	1	1	Vide Artificer's Tools.

ART.

Siege Artillery.

The quantity of artillery required for the attack of a fortified place, depends on its situation and extent,—the construction and condition of the works,—the strength of the garrison, and the character of the troops composing it,—the proposed plan of attack, and the expected duration of the siege.

In order, therefore, that the Commanding Officer of Artillery may prepare an estimate of the quantity of ordnance and ammunition required, the Commander of the Forces, or General, charged with the Direction of the Siege, should provide him, if possible, with a plan of the fortifications and environs of the place, together with such profiles and remarks as may enable him, in conjunction with the Commanding Engineer, to ascertain which front or fronts are most assailable, with the advantages or disadvantages likely to attend each attack. He should also be informed as to the quantity and nature of the ordnance mounted on the works,—the supply of ammunition with which it is provided; and whether the town is populous, and the inhabitants expected to give their zealous assistance in its defence. But the most important information which he can receive, on this point, concerns the state of the garrison,—whether it is composed of veterans, or raw levies, and whether the Governor has a character for resolution and military talent. On these data, he may, in nine cases out of ten, form a tolerably accurate opinion of the value and importance attached to the place,—of its means of defence, and of the degree of resistance to be expected; since it is not for a moment to be presumed, that any government would shut up a brave and numerous force in an ill-fortified and badly-provisioned place, at the risk of seeing it sacrificed after a short resistance.

If, however, as is generally the case, the officer charged to prepare the estimate cannot procure sufficient information on these points before-hand, he must depend on a calculation of chances, and have recourse to those general principles which apply in all situations. He must endeavour to ascertain—according to the fundamental maxim of all besiegers—against which front or fronts of the place the attack can be made with the least exposure and greatest expedition, whether the siege can be most advantageously carried on by regular approaches, by taking advantage of any cover in the vicinity to break ground close to the walls, or by battering them from a distance.

GENERAL PRINCIPLES APPLICABLE TO THE ATTACK OF FORTIFIED PLACES.

1. To insure the speedy reduction of a fortified place, the besiegers must support their operations, by a fire, constantly superior to that which the besieged can oppose to them.

Consequently—

2. Every line or face of the works bearing upon the attack,—on the prolongation of which it may be possible to establish a battery,—must be enfiladed by from three to five pieces of ordnance.

3. The fire of each of the defiladed lines or faces must be silenced by a direct battery; each of these batteries should therefore contain three pieces of ordnance for every two that the besieged can oppose to it. (Vide maxim 7, Field Artillery.)

4. If the non-defiladed lines or faces be covered by a glacis, from two to three howitzers, and from four to five small mortars must be provided in addition to the above; the former to sweep the branches of the covered-

way, the latter to overwhelm the besieged in the re-entering places of arms.

Supposing, then, that an attack is to be directed on two ravelins, and the intermediate bastion of a regular hexagon, fortified according to Vauban or Cormontaigne, and that the right face of the left-hand ravelin is defiladed, the following proportion of artillery will be required,—

To enfilade the faces of the front bastion, and the branches of the opposite covered-way	10	to	14	pieces
enfilade the faces (bearing on the attack) of the collateral bastions, and the branches of their opposite covered-ways	10	„	14	„
enfilade the faces of the right ravelin, and the branches of its covered-way	12	„	16	„
enfilade the left face of the left ravelin, and the opposite branch of the covered-way	6	„	8	„
To silence the fire of the right, or defiladed face of the left ravelin	15	„	18	„
To fire into the re-entering places of arms, and the defiladed branch of the covered-way	25	„	30	„
To gain possession of the covered-way	78	to	100	pieces

Lastly, a further supply of from 30 to 40 heavy guns will be required for the breaching batteries.

CALIBRE OF THE ORDNANCE AND RELATIVE PROPORTIONS OF THE SEVERAL NATURES TO EACH OTHER.

Guns:—Of the whole number required:—

24-Pounders, $\frac{2}{3}$. 12-Pounders, $\frac{1}{3}$.

Howitzers:—One for every four guns:—

10-Inch, $\frac{1}{3}$. 8-Inch, $\frac{2}{3}$.

Mortars:—Thirteen for every twelve guns:—

10-Inch, $\frac{2}{13}$. 8-Inch, $\frac{3}{13}$.
$5\frac{1}{2}$ „ $\frac{4}{13}$. $4\frac{2}{5}$ „ $\frac{4}{13}$.

BASIS ON WHICH THE SUPPLY OF ARTILLERY AMMUNITION FOR THE SIEGE OF A FORTIFIED PLACE IS USUALLY CALCULATED.

Guns:—	24-Pounders	1150	Rounds per Gun.
	12 „	1350	„ „
Howitzers:—	10-Inch	610	Rounds per Howitzer.
	8 „	610	„ „
Mortars:—	10-Inch	660	Rounds per Mortar.
	8 „	610	„ „
	5½ „	200	„ „
	4⅖ „	200	„ „

APPLICATION OF ARTILLERY IN THE ATTACK OF FORTIFIED PLACES.

The employment of artillery at a siege, has for its object, to cover and protect the operations of the attack,—to destroy the enemy's defences,—to silence his fire,—and, finally, to breach the walls, and thus open to the besiegers, a road into the place.

The batteries intended to cover and protect the operations carried on from the first parallel, are therefore usually established in its immediate vicinity—sometimes within the parallel itself—and should contain each from 8 to 10 pieces of ordnance. The object of the besiegers, in establishing these batteries, is, to drive the enemy from his outworks,—to intercept his communications,—and to dismount that part of his artillery which would, if it were not silenced, sensibly retard the progress of the approaches towards the place. The most advantageous sites that can be chosen for them, with reference to the defences of the place, will consequently be, on, and perpendicular to, the prolongations of such of the faces of the works, as are subject to be enfiladed. But, if these positions cannot be attained, either on account of the disposition of the works, or the nature of the ground, they should be established within the prolongations, so as to take the faces in reverse. If neither of these last-mentioned positions can be occupied by enfilading, or ricochet batteries, the battery to destroy the defences of a face, must be posted without its prolongation, so as to fire, under as small an angle as possible, obliquely across the parapet, and thus plunge into the rear of the adjoining flank. The last position, in point of advantage, which can be occupied by the first batteries,—from which a vigorous, and incessant fire must be kept up, more particularly at the commencement of the siege, and which should, if possible, continue open till the besiegers arrive on the crest of the glacis,—is, directly parallel to the face, to the defences of which they are to be opposed.

Under the protection afforded by the fire of these batteries, the engineers are enabled to push forward the approaches, till they arrive at those points, through which it is intended to run the second parallel; that is, till they meet the musquetry fire of the covered-way. Arrived at these points, it sometimes happens that the works, which the construction of this parallel necessitate, unavoidably mask the fire of the first batteries. Should this prove to be the case, the artillery must be removed from them, into fresh batteries now to be prepared for its reception. In the choice of the sites for these second batteries, not only must the objects for the attainment of which the first were established, be kept steadily in view, but situations should also be selected, on which to erect howitzer, and mortar batteries, to ricochet the flanks of the bastions, and to annoy the defenders of the curtains.

The approaches are next pushed forward to about midway between these positions, and the crest of the glacis; at which distance, the sappers, being within reach of sudden sallies from the garrison, and exposed to an effective musquetry fire from the place, they require a more proximate protection than can be afforded by the troops stationed in the second parallel; demi-parallels are therefore now constructed, and howitzers placed in battery in their extremities, to sweep the branches of the covered-way, and endeavour to silence the musquetry of its defenders.

The third parallel, which is usually run at the foot of the glacis, affords positions, from which the defences of the place may be still further assailed, and the musquetry fire of the defenders of the covered-way totally silenced. The batteries established for these purposes, are sometimes armed with howitzers, but more frequently with small mortars; the former to ricochet the faces of the ravelins and bastions; the latter to search into the places of arms, behind the traverses, and generally into all the defiladed defences.

As soon as the batteries planted in the third parallel are equipped, and ready to open their fire, the approaches are again pushed forward,—the covered-way is attacked, and counter and breaching batteries are established on its branches;—the former, to destroy such of the flank defences as still remain intact;—the latter, to open the revetments, and secure a passage into the place. The breaching batteries are usually placed opposite that part of the covered-way, which is included between the first and second traverses;—the counter batteries, on the branches of the saliant places of arms;—those established on the saliants of the ravelins, should therefore direct all their efforts to open the opposite faces of the bastions, and thus expose the contiguous flanks to be enfiladed, or seen in reverse from the third, and demi parallels, while those established on the saliants of the bastions endeavour to encounter their direct fires.

COMPOSITION of a BATTERING TRAIN of One Hundred and Forty Pieces of Ordnance.

ORDNANCE, ETC.	Number.	OBSERVATIONS.
ORDNANCE.		
Guns 24-Pounders	40	In many cases, more guns with the same quantity of ammunition would be better and cheaper; and, as each Battering Train must be formed with reference to its particular destination, this scale is of course subject to modification.
Guns 12 ”	20	
Howitzers 10-Inch	5	
Howitzers 8 ”	10	
Mortars 10-Inch	10	
Mortars 8 ”	15	
Mortars 5½ ”	20	
Mortars 4⅖ ”	20	
CARRIAGES.		
Gun 24-Pounder	40	1 for each Gun.
Gun ” ”	4	1 ” 10 ” Spare.
Gun 12 ”	20	1 ” each Gun.
Gun ” ”	2	1 ” 10 ” Spare.
Howitzer 10-Inch	5	1 for each Howitzer.
Howitzer ” ”	1	1 ” 5 ” Spare.
Howitzer 8 ”	10	1 ” each Howitzer.
Howitzer ” ”	1	1 ” 10 ” Spare.
Mortar Beds	65	1 for each Mortar.
Waggons Platform 10-Inch	10	1 for each 10-Inch Mortar.
Waggons Platform 8 ”	8	1 for every 2, 8-Inch Mortars.
Waggons Platform Spare	4	1 in 5 for Mortars.
Waggons Platform 24-Pounder. 10-Inch	3	1 for every 5, 24-Pounders, and 10-Inch Howitzers.
Waggons Flanders	100	1 for each piece of Hy. Ordnance
Waggons Store	10	1 for every 10 pieces of Heavy Ordnance.
Waggons Forge	10	1 ” 10 ” ”
Carts Sling	10	1 ” 10 ” ”
Carts Hand	50	1 ” 2 ” ”
Carts Trench	50	1 ” 2 ” ”
Drags Large	5	1 ” 20 ” ”
Drags Small	5	1 ” 20 ” ”
Devil-Carriages (Small)	2	1 for every 30 Guns.

ART.

PERSONNEL, ETC. for a Battering Train of One Hundred and Forty Pieces of Ordnance.

PERSONNEL, ETC.	Number.	OBSERVATIONS.
GUNNERS, ETC.		
Colonels		*Vide* "Exercise of Siege Artillery" for the detail of Non-Commissioned Officers and Gunners required for the Service of the Ordnance.
Lieutenant-Colonels		
First Captains		
Second "		
First Lieutenants		
Second "		The reserve, to replace casualties, etc., is usually calculated on the basis of one man for each piece of Ordnance. The basis for the laboratory duties is one man for every two pieces of Heavy Ordnance.
Surgeons		
Serjeants		
Corporals		
Bombardiers		
Drummers or Buglers		
Gunners		
Total		
DRIVERS, ETC.		
Staff-Serjeants		
Serjeants		
Corporals		
Buglers or Trumpeters		
Wheelers	6	Including a Master Artificer.
Collar-Makers	5	
Coopers	2	
Carriage-Smiths	7	
Shoeing "		
Farriers		
Drivers		
Total		
FIELD TRAIN.		
Commissaries	1	
Assistant Commissaries	3	1 for the Shipping. 1 " " Laboratory. 1 " " Park.
Clerks of Stores	8	
Conductors	8	
Total	20	
HORSES OR MULES.		
Riding		
" Spare		
Draft	1424	*Vide* "Horses" for the distribution to the several carriages.
" Spare		
Baggage		
Total		

DETAIL of a PROPORTION of AMMUNITION, ETC. for a Battering Train of One Hundred and Forty Pieces of Ordnance.

AMMUNITION, ETC.	Number.	OBSERVATIONS.
Shot Round 24-Pounder	40000	1000 Rds. per Gun.
Shot Round 12 ,,	24000	1200 ,, ,, ,,
Shot Case Tier 24-Pounder.	2000	50 ,, ,, ,,
Shot Case Tier 12 ,,	1000	50 ,, ,, ,,
Shot Case Spherical 24-Por	4000	100 ,, ,, ,,
Shot Case Spherical 12 ,,	2000	100 ,, ,, ,,
Shot Case Spherical 8-Inch	3000	300 ,, ,, 8-In. Howitzer.
Shot Pound (Rds. 100 in each)	500	50 ,, ,, 10-In. Mortar.
Wood Bottoms	500	1 per Round of Pound Shot.
Shells 10-Inch	9000	600 per 10-In. How. & Mortar.
Shells 8 ,,	12000	300 per 8-In. How., 600 per 8-In. Mortar.
Shells 5½ ,,	4000	200 per 5½-Inch Mortar.
Shells 4⅖ ,,	4000	200 ,, 4⅖ ,, ,,
Carcases, Fixed	400	10 per Heavy How. & Mortar.
Valenciennes, Composition	1500	100 proportions per 10 and 8-In. Howitzer & Mortar.
Gunpowder Bars Whole L.G	5024	Calculated at the Full Service Charge, exclusive of Cartridges, for each round.
Gunpowder Bars Half F.G.	400	
Gunpowder Mealed	100	1 lb. per piece Hy. Ordnance.
Cartridges Filled, Full Charge	10500	150 per Gun, & 100 per How.
Cartridges Empty Full Chge.	79500	1 per round, including those filled, & 1-10 spare per Gun.
Cartridges Empty Eight oz.	..	½ No. Rds. per Small Mortar.
Worsted ... lbs.	19	¼ for each Gun and Howitzer.
Needles	125	3 ,, ,, ,,
Paper Caps (in lieu of Wads)	32000	1 for every 2 Rounds.
Choaking Twine	..	1 lb. for every 1000 Cartridges.
Packthread	..	1 ,, 1000 ,,
Wads	6400	1 for every 10 Rounds.
Fuzes, Common, Graduated	43500	3 ,, 2 Shells.
,, Spherical	18000	2 for each Shell.
Tubes (Brass)	126540	1 for each Rds. and 1-5th Spare.
Slow-match	27	¼ cwt. per piece Hy. Ordnance,
Quick-match, Lengths	15000	600 per 10 and 8-Inch Mortar.
,, Balls	400	
Portfires, Long, Small	2739	1 for every 12 Rounds.
,, Blue Paper	5478	
Flints	1375	25 for each Lock in Action.
Blue Lights (for Signals)	100	1 for each piece Hy. Ordnance.

IMPLEMENTS and STORES for a Battering Train of One Hundred and Forty Pieces of Ordnance.

IMPLEMENTS, ETC.	Number.	OBSERVATIONS.
Spunges and Rammers..	215	2 per Gun and How. and 1 per Mortar.
„ Staves (Spare)..	215	2 „ „ 1 „
„ Heads „ ..	240	2 per Gun, How., and Hy. Mortar, and 1 for each Small Mortar.
Tube-Pockets	240	2 „ „ „ „
Thumbstalls	240	2 „ „ „ „
Portfire-Sticks	240	2 „ „ „ „
„ Clippers	70	1 for every 2 pieces of Ordnance.
Saws, Tenon	70	1 „ 2 „ „
„ Setters	70	1 „ 2 „ „
„ Files, 3-square	70	1 „ 2 „ „
Water-Buckets (Leather).	208	2 per piece Hy. Ord. 1 for 5 Mortars.
Rammer-Heads (Spare)..	..	2 for each Gun and Howitzer.
Side-Arm Straps...sets..	75	1 „ „ „
Grease Boxes	75	1 „ „ „
Wadhooks	15	1 for every 4 Guns.
Ladles	15	1 „ 4 „
Handspikes, Traversing..	30	1 for each 12-Por. and 8-In. Howitzer.
„ Common ..	310	4 „ 24-Por. 10-In. How. & Mor., 2 for each 12-Por. 8-In. How.&Mortar.
Handcrow Levers (6-feet)	75	1 per Gun, & 10-In. How. & Mortar.
Crowbars (5½ feet)	10	1 for every 10 Guns, Howitzers, and Heavy Mortars.
Jacks (Handscrew)	20	1 „ 5 „ „
Claw-Hammers	100	1 for each Gun, How. and Hy. Mortar.
Spikes (Common)	500	5 „ „ „ „
Powder Measures, „ (1oz. to 4lbs.) sets	20	1 for 5 Guns, How., and Hy. Mortars.
„ Horns	140	1 for each piece of Ordnance.
Vent Punches	280	2 „ „ „
Priming-Irons ....sets	140	1 „ „ „
Lintstocks	140	1 „ „ „
Cutting-Knives	140	1 „ „ „
Scissors ....pairs	140	1 „ „ „
Cartouches, Leather	140	1 „ „ „
„ Wood	120	2 for each Gun.
Funnels, Loading	13	1 for every 2,—10 and 8-Inch Mortars.
„ for Shells	55	1 for 4 Guns; and 1 for 2 Howitzers, and Mortars.
Gun-locks	83	1 for every Gun and How. and 1-10 Spare.
Quadrants	8	1 for every 5 How., 10 and 8-In. Mortars.
Perpendiculars	8	1 „ 5 „ „ „
Fuze-Engines	8	1 „ 5 „ „ „

IMPLEMENTS AND STORES—*continued.*

IMPLEMENTS, ETC.	Number.	OBSERVATIONS.
Pincers	8	1 for every 5 Small Mortars.
Budge Barrels	50	1 for each Howitzer and Mortar, and 1 for every 5 Small Mortars.
Compasses ....pairs	8	1 for every 5 How., & 10 & 8-in. Mortar.
Rules, Box	20	1 „ 5 Guns, How. & Hy. „
Corkscrews	55	1 „ 4 Guns, and 1 for every 2 Howitzers and Mortars.
Shell Scrapers	40	1 „ 2 Howitzers and Mortars.
„ Hooks (Hand)	30	2 „ 10-in. Howitzer and Mortar.
Mallets	80	1 for each Howitzer and Mortar.
Setters	160	2 „ „ „
Lead Plummets	45	1 „ Mortar.
Harness, Men's.....sets	150	2 per 24-Por., 10-in. How. & Mortar, 1 per 12-Por., 8-in. How. & Mortar.
„ Horses.... „	..	Vide Harness.
Hoops (Hazle)		1 for every 10 Powder Barrels.
Adzes (Copper)		1 Set for every 500 Barrels of Powder.
Drivers „		
Vices „		
Canhooks „		
Beams and Scales	9	1 for every 5 Hy., and 10 Small Mortars.
Weights (4 lb. piles)	9	1 „ 5 „ 10 „
Gyns, Triangle	8	2 „ 25 pieces of Heavy Ordnance.
Blocks, Treble (Iron)	..	Complete for 8 Gyns.
„ Double „	..	
Rope, White, Slings (6-In.) fth	..	
Rope, White, Falls (4-In.) „	..	
Purchase Blocks, Treble	5	1 for every 20 pieces of Hy. Ordnance.
Purchase Blocks, Double	5	
Purchase Blocks, Single	5	
Rope (4½-In. tarred) coils	4	1 „ 25 „ „
Blocks, Double, 10-In.	8	Equal to the number of Gyns.
Blocks, Double, 8 „	8	
Blocks, Single, 10 „	8	
Blocks, Single, 8 „	8	
Blocks, Single, 5½ „	8	
Rope, Tarred, 4-in. coils	4	1 for 25 pieces of Heavy Ordnance.
Rope, Tarred, 3 „ „	5	1 „ 20 „ „ „
Rope, Tarred, 2 „ „	5	1 „ 20 „ „ „
Rope, Tarred, 1 „ „	10	1 „ 10 „ „ „
Rope, White, 6 „ „	1	1 „ 100 „ „ „
Rope, White, 4 „ „	1	1 „ 100 „ „ „
Rope, White, 3 „ „	1	1 „ 100 „ „ „
Rope, White, 2 „ „	1	1 „ 100 „ „ „

Implements and Stores—*continued.*

IMPLEMENTS, etc.	Number.	Observations.
Crab Capstans	2	1 for 50 pieces of Hy. Ordnance
Spunyarn coils	5	1 for 20 ,, ,, ,,
Ratline ,,	5	1 ,, 20 ,, ,, ,,
Coals chals.	5	1 ,, 20 ,, ,, ,,
Candles cwt.	1	1 ,, 100 ,, ,, ,,
Steel, Sheer ,,	1	1 ,, ,, ,, ,, ,,
,, Blister ,,	1	1 ,, ,, ,, ,, ,,
Iron (Assorted)	..	1 Ton for 50 pieces of Hy. Ordnance.
Grease kegs	200	2 for each piece of Hy. Ordnance.
Lanterns, Muscovy	10	1 for 10 pieces ,, ,,
,, Tin	20	1 ,, 5 ,, ,, ,,
,, Dark	20	1 ,, 5 ,, ,, ,,
Axes, Felling	50	1 ,, 2 ,, ,, ,,
,, Pick	100	1 ,, each ,, ,, ,,
Spades	100	1 ,, ,, ,, ,, ,,
Shovels	100	1 ,, ,, ,, ,, ,,
Hand-Bills	100	1 ,, ,, ,, ,, ,,
Hatchets	100	1 ,, ,, ,, ,, ,,
Barrows, Hand	50	1 ,, 2 ,, ,, ,,
,, Wheel	50	1 ,, 2 ,, ,, ,,
Grindstones	2	1 ,, 50 ,, ,, ,,
Helves, Spade	50	1 ,, 2 ,, ,, ,,
,, Shovel	50	1 ,, 2 ,, ,, ,,
,, Felling Axe	25	1 ,, 4 ,, ,, ,,
,, Pickaxe	50	1 ,, 2 ,, ,, ,,
Saws, Pit	2	1 ,, 50 ,, ,, ,,
,, Cross-Cut	2	1 ,, 50 ,, ,, ,,
,, Hand	10	1 ,, 10 ,, ,, ,,
,, Setters, Pit	2	1 for each Saw.
,, ,, Cross-Cut	2	1 ,, ,, ,,
,, ,, Hand	2	1 ,, 5 ,,
,, Files, Pit	24	12 ,, each ,,
,, ,, Cross-Cut	24	12 ,, ,, ,,
,, ,, Hand	36	18 ,, 5 ,,
Hides (Tanned)	50	1 for 10 pieces of Heavy Ordnance.
Wadmiltilts	50	1 ,, 10 ,, ,, ,,
Hair-Cloths	100	1 ,, each ,, ,, ,,
Tarpaulins, 30 feet by 15 feet.	25	1 ,, 4 ,, ,, ,,
,, 20 ,, 16 ,,	25	1 ,, 4 ,, ,, ,,
,, 14 ,, 10 ,,	100	1 ,, each ,, ,, ,,
Horse-Shoes sets	..	3 for every single Horse Harness.
Horse-Shoe Nails sets	..	3 to each set of Shoes.
Park Pickets	..	1 for 5 single Horse Harness.
Wood Mauls	..	1 ,, 10 pickets.

Implements and Stores—*continued.*

IMPLEMENTS, ETC.			Number.	OBSERVATIONS.
Nose-Bags (Canvas)			..	3 for every 2 Horse Harness.
Corn-Sacks			..	1 for 2 Horse Harness.
Forage-Cords ... sets			..	1 ,, 2 ,, ,,
Head-Collars (additional)			..	1 for 5 sets single ,, ,,
Sledge Hammers (Heavy)			4	1 ,, 25 pieces of Hy. Ordnance.
Wrench ,, (of sizes)			10	1 ,, 10 ,, ,, ,,
Screws (Assorted) ... gross			10	1 ,, 10 ,, ,, ,,
Marline-Spikes			4	1 ,, 25 ,, ,, ,,
Glue ... lbs.			10	1 ,, 10 ,, ,, ,,
Nails	Streak (Assorted)		3000	30 for each piece ,, ,,
	Clasp	40 penny	3000	30 ,, ,, ,, ,, ,,
		30 ,,	2000	20 ,, ,, ,, ,, ,,
		20 ,,	4000	40 ,, ,, ,, ,, ,,
		10 ,,	4000	40 ,, ,, ,, ,, ,,
		6 ,,	2000	20 ,, ,, ,, ,, ,,
Plank	Elm	1-in. (super ft.)	50	1 for 2 pieces of Hy. Ordnance.
		¾ ,, ,,	50	1 ,, 2 ,, ,, ,,
	Ash	1½ Inch		
		1 ,,		
Deals Sawed			25	1 for 4 pieces of Hy. Ordnance.
,, Whole			25	1 ,, 4 ,, ,, ,,
Guages (Shot) ... sets			4	1 ,, 25 ,, ,, ,,
Calippers (Large) ... pairs			2	1 ,, 50 ,, ,, ,,
Grates (for Heating Shot)			3	1 for every 20 Guns.
Fire-Irons and Shot-Bearers				In proportion to the Grates.
Gun	24-Pounder	Gun	8	Wheels;—1 for every 5 Guns and Howitzers, and 1 for every 20 Gun and Howitzer Limbers and the wheels of all other carriages.
		Limber	4	
	12-Pounder	Gun	4	
		Limber	2	
Howitzer	10-Inch	Howitzer	1	
		Limber		
	8-Inch	Howitzer	2	
		Limber	1	
Waggons	Flanders	Fore	10	
		Hind	10	
	Forge		2	
	Platform	Fore	3	
		Hind	3	
Carts	Sling		2	
	Hand		5	
	Trench		5	
Handspikes, Common (Spare)			300	3 for each piece of Hy. Ordnance
,, Traversing ,,			15	1 for 2, 12-Pors. & 8-in. Howitzers
Bail-Hoops ,,			200	2 for each Flanders Waggon.

IMPLEMENTS AND STORES—*continued.*

IMPLEMENTS, ETC.	Number.	OBSERVATIONS.
Axletrees, Gun, 24-Pounder	5	1 for every 10 Guns and Howitzers, with Wood Beds in proportion.
,, ,, 12 ,,	3	
,, Howitzer, 10-Inch	5	
,, ,, 8 ,,	3	
Axletree Arms (Assorted)	35	1 for every 10 Carriages.
Spokes (Assorted)		1 for each Spare Wheel.
Fellies ,,		1 ,, ,, ,,
Shafts ,,	70	1 for every 5 Carriages.
Splinter Bars ,,	25	1 ,, 10,—4-wheel Carriages
Guides, Fore	12	1 ,, 20 ,, ,,
,, Hind	12	1 ,, 20 ,, ,,
Shaft Bars (Assorted)	25	1 ,, 10 ,, ,,
Underpoles	10	1 for every 10 Flanders Waggon.
Naves	10	1 ,, 10 ,, ,,
Tail Pieces	10	1 ,, 10 ,, ,,
Sweep Bars	10	1 ,, 10 ,, ,,
Iron Tyres	..	Equal ½ mat. for repairing wheels
Laboratory Tents	5	1 for 20 pieces of Hy. Ordnance
Hides, Stout	14	1 for 100 sets of single Harness.
,, Light	7	1 ,, 200 ,, ,, ,,
Bazils (Assorted)	28	2 doz. for each 100 sets ,,
Webb, Girth	112	8 yds. ,, 100 ,, ,,
,, Surcingle	42	3 ,, ,, 100 ,, ,,
Serge (Pannel)	70	5 ,, ,, 100 ,, ,,
Doe's or Curled Hair	210	15 lbs. ,, 100 ,, ,,
Thread, Hemp	42	3 ,, ,, 100 ,, ,,
,, Collar	28	2 ,, ,, 100 ,, ,,
,, Dutch	28	2 ,, ,, 100 ,, ,,
Buckles (Assorted)	42	3 doz. ,, 100 ,, ,,
Nails (Collar-Maker's)	7000	500 ,, 100 ,, ,,
Tacks ,,	7000	500 ,, 100 ,, ,,
Bristles	7	1 lb. ,, 200 ,, ,,
Needles (Assorted)	1400	100 ,, 100 ,, ,,
Whipcord	21	3 lbs. ,, 200 ,, ,,
Tin-Pans (Oil)	..	2 ,, 100 ,, ,,
Wax, Black	42	3 lbs. ,, 100 ,, ,,
,, Bees'	14	1 ,, ,, 100 ,, ,,
Oil, Neats' Foot	21	3 galls, ,, 200 ,, ,,
Tallow	14	1 lb. ,, 100 ,, ,,
Collar-Maker's Tools	4	1 for 25 pieces of Hy. Ordnance.
Wheeler's ,,	8	2 ,, 25 ,, ,, ,,
Carriage-Smith's ,,	4	1 ,, 25 ,, ,, ,,
Shoeing-Smith's ,,	..	1 set for 50 sets of single harness.
Cooper's ,,	2	1 ,, 50 pieces of Hy. Ordnance.

ART.

Garrison Artillery.

The proportion of ordnance, ammunition, and stores required for the defence of a fortified place, depends, not only on the particular situation of each individual fortress, and its relation with the surrounding country, —the system according to which it is fortified,—and the species of attack which it may be possible to open against it, but likewise, on innumerable minor circumstances, each of which may exert an important influence on the defence.

If one or more of the fronts of a place, be covered by an inundation, a marsh, or by any other impassable obstacle, it will manifestly require a much smaller proportion of artillery, for its defence, than if all its fronts were equally accessible. A maritime fortress, on the other hand, which is susceptible of attack both by sea and land, will require a larger proportion of ordnance supplies, than if it were accessible from only one of these points.

It is obvious, therefore, that no unvarying and definite rules can be laid down for the arming of fortified places. The only plan that an officer charged with this very important trust can with safety follow, is—after an attentive study of the nature and disposition of the works, and their relation with the surrounding country—to recur to those fundamental principles upon which a scientific attack and defence must be invariably founded;—to weigh maturely every circumstance that can, in any degree, influence his own, or the beseigers' operations; and to take into his consideration, not only the minutest details of his own particular branch of the service, but also, those operations of the defence, in which the other troops of the garrison are to bear their part; so that every supply may be adequate to its intended purpose, without superfluity on the one hand, or deficiency on the other. By these means, two extremes, equally prejudicial, will be avoided,—the one, of making a provision insufficient for the defence which the place is capable of sustaining, —the other, of providing such a supply, that on its surrender, a complete arsenal would fall into the enemy's hands.

GENERAL PRINCIPLES APPLICABLE TO THE ARMING OF FORTIFIED PLACES.

1. The proportion of ordnance, ammunition, and stores, provided for the armament of a fortified place, should never exceed the quantity absolutely necessary to a brave and resolute defence.

Consequently—

2. Those fronts only which are considered susceptible of attack, should be completely armed.

3. Each of the faces of the bastions, of these fronts, will require from 5 to 6 pieces of ordnance;—each of the flanks, 4 pieces;—and each of the faces of the ravelins, from 4 to 5 pieces.

4. If the works be covered by lunettes, 4 pieces of ordnance must be reckoned for each of them;—and from 2 to 3 pieces for each of the places of arms of the covered-way.

5. The remaining fronts must each be provided with such a proportion of its full armament, as will secure it from insult.

Supposing therefore, that only one front of attack, of a place fortified according to Vauban or Cormontaigne, is to be completely armed, the following will be the proporition of artillery required for that purpose :—

For the 4 faces of the 2 bastions, ...	20	to	24	pieces
2 interior flanks of these bastions, ..	8	„	8	„
4 faces of the ravelins, ...	16	„	20	„
5 places of arms of the covered-way,..	10	„	15	„
Total for one front of attack, ..	54	to	67	pieces

6. If the place be liable to attack on two consecutive fronts, this proportion must be encreased one-half;—if on two detached fronts, it should be doubled.

Thus, it will appear, that on these principles, a hexagon having only one of its fronts exposed to attack, requires from 70 to 87 pieces of ordnance for its defence, and that, for more extensive places, from 6 to 8, or at most 10 pieces, should be added, for each additional front.

CALIBRE OF THE ORDNANCE, AND RELATIVE PROPORTIONS OF THE SEVERAL NATURES TO EACH OTHER.

Guns:—Of the whole number required:—

24-Pounders	$\frac{1}{5}$	18-Pounders	$\frac{1}{5}$
12 „	$\frac{2}{5}$	6 „	$\frac{1}{5}$

Howitzers:—One for every four guns:—

8-Inch	$\frac{1}{3}$	5½-Inch	$\frac{2}{3}$

Mortars:—Two for every howitzer:—

10-Inch	$\frac{1}{5}$	8-Inch	$\frac{2}{5}$
5½ „	$\frac{1}{5}$	$4\frac{2}{5}$ „	$\frac{1}{5}$

BASIS, ON WHICH THE SUPPLY OF ARTILLERY AMMUNITION FOR THE DEFENCE OF A FORTIFIED PLACE IS USUALLY CALCULATED.

Guns:—24-Pounders	600	Rounds per Gun.
18 „	740	„ „
12 „	900	„ „
6 „	1050	„ „

Howitzers:—	8-Inch	660	Rounds per Howitzer.
	5½ „	610	„ „
Mortars:—	10-Inch	450	Rounds per Mortar.
	8 „	600	„ „
	5½ „	400	„ „
	4⅖ „	400	„ „

APPLICATION OF ARTILLERY IN THE DEFENCE OF FORTIFIED PLACES.

The objects to be obtained by artillery employed in the defence of a fortified place, are, to throw back, particularly at the commencement of the siege, the enemy's operations to the greatest possible distance from the works,—to combat his batteries,—to protract the progress of the approaches,—and, finally, to encounter, and endeavour to overwhelm the assailants in their efforts to force a passage through the breach.

The instant it is ascertained therefore, that the enemy is in motion towards the place, preparations must be made for the reception of the investing corps. The barbette batteries, established in the flanked angles of the bastions, and ravelins, must be armed, and a proportion of the light guns and howitzers must be placed in the outworks and covered-way. The heavy mortars should be distributed among the several bastions, and the remainder of the ordnance should be placed, in reserve, behind the curtains. By this arrangement, the whole of the barbette guns, and the guns, and howitzers in the outworks and covered-way, will be in readiness to act in any direction, that may be required, till it is discovered against which front the enemy has determined to direct his attack. In the first moments of the investment however, the artillery of the place should not, by a useless expenditure of ammunition, endeavour to disturb the besieger's operations. It is only when his dispositions evince an intention to undertake the siege in earnest, that the fire of the garrison should be opened upon him.

Ground being broken, and the investment completed, a new disposition of the artillery of the place, must be made. The enemy's motions should now be closely watched, and, should they indicate the positions chosen for his first batteries, the fire of every gun, howitzer, and mortar that can be brought to bear on them, should be opened on those points. The mortars, which had heretofore been fired at low angles, should now also fire at greater elevations, but at all times sparingly; and, towards evening, the requisite steps must be taken, to insure a constant, and powerful fire during the night, on the enemy's position generally, but especially on his communications with the rear.

As soon as the enemy's first batteries are fairly established, and armed, the guns en barbette must be covered by merlons, platforms must be laid, and the embrazures occasionally masked. While this work is carrying on, the situations of the guns should be changed, and their fire directed on other objects. By practising this manœuvre as often as opportunities offer, the enemy will be obliged to change his dispositions, and time will thereby be gained by the besieged. Should the besieger, as is sometimes the practice, open the fire of his batteries one after another as they are established, and armed, instant advantage must be taken of his error, and every exertion must be made, to crush them in succession, by a concentrated, and vigorous fire.

The next step of the besieger—his batteries being now in full operation—will be to push forward the approaches to the second parallel, and, in order to meet him, the fire of the place must be spread over all parts of his line of operations. Having completed this parallel, he will next endeavour to débouch from it, and commence the construction of the demi-parallels. To counteract these efforts, the fire of the garrison must be concentrated on the heads of the saps; and the small mortars—arranged in the places of arms, and branches of the covered-way—must be brought into play, with all possible activity.

As soon as the demi-parallels are established, and armed, the guns, and howitzers in the covered-way must be withdrawn from it, to the ditches, if dry, to the ravelins, or to other favourable situations; and by degrees, as the enemy advances, to the body of the place. Embrazures must now also be prepared in the flanks, in the curtain, which joins them, and in those parts of the faces of the bastions which command the ditch of the front ravelin. The whole of these batteries must be armed, in readiness to open their fire the instant the enemy attempts to form a lodgment, on the crest of the glacis.

The besieger, having completed his third parallel, established himself, on the crest of the glacis, effected a descent into the ditch, and commenced the construction of an epaulment, to cover and protect his approach to the foot of the breach, a last energetic effort must now be made to arrest his farther progress. The whole of the mortars must be brought into play;—a powerful vertical fire must be opened on the lodgment, on the communications with the third parallel, and on the returns of the saliant places of arms of the covered-way;—an incessant fire must be kept up, on the epaulment and the debouchée from the counterscarp;—loaded shells must be rolled over the parapet on the heads of the sappers;—and the instant the enemy's columns advance to the assault, grenades powder-bags and every other possible description of missile, must be showered on them from all parts of the works.

Composition of an Artillery Armament for the Defence of a Fortified Place.

ORDNANCE, ETC.			Number.	OBSERVATIONS.
Ordnance.				
Guns	24-Pounders		12	In estimating the relative proportions of the several calibres, it must be remembered that the higher rates are not the only description capable of being employed to advantage. Medium guns in many situations oppose an equal resistance with the heavier natures:—they also consume less ammunition, and enable the besieged to keep up a more determined& incessant fire.
	18 „		12	
	12 „		24	
	6 „		12	
Howitzers	8-Inch		5	
	5½ „		10	
Mortars	10-Inch		6	
	8 „		12	
	5½ „		6	
	4⅖ „		6	
Carriages.				
Gun	24-Pounder	Garrison		
		Siege		
	18 „	Garrison		3 for every 2 Guns and Howitzers, if the means of repairing accidents are provided. If not, 4 for every 2 Guns and Howitzers.
		Siege		
	12 „	Garrison		
		Siege		The proportion of Siege and Field Carriages allowed, is usually 1 for every 2 Guns or Howitzers, complete with Limbers, etc.
	6 „	Garrison		
		Field		
Howitzer	8-In.	Garrison		
		Siege		
	5½ „	Garrison		
		Field		
Mortar-Beds	Iron			1 for each Mortar.
	Wood			7 for every 6 Mortars.
Devil-Carriages	Large			1 for every 6, 24, & 18-Pounder and 10-Inch Mortars.
	Small			1 for every 6, 12-Pounders.
Drags	Large			1 for every 4 Small Mortars.
	Small			
Carts	Sling			1 for every 15 pieces Hy. Ordnance.
	Hand (Ammunition)			2 for each Battery.
Platform-Waggons				1 for every 7 pieces Hy. Ordnance.

PERSONNEL, ETC. for the Service of the Artillery in the Defence of a Fortified Place.

PERSONNEL, ETC.	Number.	OBSERVATIONS.
GUNNERS, ETC.		
Colonels		
Lieutenant-Colonels		
First Captains		
Second ,,		*Vide* "Exercise of Garrison Artillery," for the detail of the Non-Commissioned Officers and Gunners required for the Service of the Ordnance.
First Lieutenants		
Second ,,		
Adjutants		
Quarter-Masters		
Surgeons		
Serjeants		
Corporals		
Bombardiers		
Drummers or Buglers		
Gunners		
Total		
DRIVERS, ETC.		
Staff-Serjeants		
Serjeants		
Corporals		
Drivers		
Total		
CIVIL DEPARTMENT.		
Storekeepers	1	
Deputy Storekeepers	2	1 for the Artificer's yard. 1 ,, Laboratory.
Master Artificers		
Wheelers		
Blacksmiths		
Collar-Makers		
Coopers		
Tinsmiths		
Carpenters		
Armourers		
Total		
HORSES AND MULES.		
Riding		
,, Spare		*Vide* "Horses" for the Number allowed for each Carriage
Draft		
,, Spare		
Total		

DETAIL of a PROPORTION of ARTILLERY AMMUNITION for the Defence of a Fortified Place.

AMMUNITION, ETC.				Number.	OBSERVATIONS.
Shot	Round		24-Pounder	6540	545 Rounds per Gun.
			18 ”	8100	675 ” ” ”
			12 ”	19800	825 ” ” ”
			6 ”	11580	965 ” ” ”
	Case	Tier	24-Pounder	240	20 ” ” ”
			18 ”	300	25 ” ” ”
			12 ”	720	30 ” ” ”
			6 ”	420	35 ” ” ”
			8-Inch	300	60 ” ” Howitzer.
			5½ ”	900	90 ” ” ”
		Spherical	24-Por.	420	35 ” ” Gun.
			18 ”	480	40 ” ” ”
			12 ”	1080	45 ” ” ”
			6 ”	600	50 ” ” ”
			8-Inch	750	150 ” ” Howitzer.
			5½ ”	1200	120 ” ” ”
	Pound (Rds. 100 in each)			2700	150 per 10 and 8-Inch Mortar.
Wood Bottoms				2700	1 for each Round of lb. Shot.
Grenades, Rampart				4300	
” Hand				20000	
Shells	10-Inch			1800	300 per Mortar.
	8 ”			7650	450 ” ” and Howitzer.
	5½ ”			6400	400 ” ” ”
	4⅖ ”			2400	400 ” ”
Light-Balls				675	15 ” ” ”
Rockets (for Signals)				100	
Gunpowder	Brls.	Whole L.G.		3480	Calculated at the Full Charge for each piece of Ordnance.
		Half F. G.		210	
	Mealed			105	1 lb. for each piece of Ordnance.
Serge yds.				10053	⅔ of the quantity required to make up the entire of the Gun and Howitzer Cartridges.
Worsted lbs.				85	
Wads				3068	1 for every 15 Rds. Round Shot.
Fuzes, Common				26750	7 for every 5 Shells,
” Spherical				6795	6 ” 4 ”.
Portfires, Long Small				1668	1 for every 15 Rounds.
” Blue Paper				3335	
Tubes				90066	6 for every 5 Rounds.
Slow-Match lbs.				2625	25 for each piece of Ordnance.
Quick-Match				105	1 ” ” ” ”
Flints				1500	20 for each Lock in Action.

IMPLEMENTS and STORES for the Service of the Artillery in the Defence of a Fortified Place.

IMPLEMENTS, ETC.	Number.	OBSERVATIONS.
Spunges and Rammers ..	175	5 for every 3 pieces of Ordnance.
,, Staves (Spare)..	210	2 for each piece of Ordnance.
,, Heads ,, ..	105	1 ,, ,, ,,
,, Caps	175	1 for each Spunge.
Rammer-Heads (Spare)..	30	1 for each Heavy Gun and Howitzer.
Wadhooks	75	5 for every 4 Guns.
Ladles	12	1 for ,, 5 ,,
Handspikes, Common ...		10 for each Siege and Garrison Carriage.
,, Traversing .		2 ,, Field Carriage.
Lintstocks		3 ,, Combination of Batteries.
Tube-Pockets	175	5 for every 3 pieces of Ordnance.
Portfire-Sticks	210	2 for each piece of Ordnance.
,, Cutters		3 ,, Combination of Batteries.
Priming-Irons..........sets	105	1 ,, piece of Ordnance.
Vent-Punches	210	2 ,, ,, ,,
Spikes, Common	210	2 ,, ,, ,,
Gunlocks	90	6 for every 5 Guns and Howitzers.
Thumbstalls	107	3 for every 2 pieces of Ordnance.
Powder-Horns	126	6 ,, 5 ,, ,,
,, Measures....sets	21	1 ,, 5 ,, ,,
Funnels, for Shells......	21	1 ,, 5 ,, ,,
,, ,, Loading....	18	1 for each Heavy Mortar.
Quadrants		2 for each Mortar or Howitzer Battery.
Perpendiculars..........		2 ,, ,, ,, ,,
Jacks, Handscrew		2 for each Battery.
,, Lifting		1 ,, ,,
Fuze Benches		2 ,, ,,
,, Knives		3 ,, Bench.
,, Augers		2 ,, ,,
,, Engines		1 ,, ,,
Compasses ....pairs		2 ,, ,,
Diagonal Scales		1 for every 2 pairs of Compasses.
Mallets		3 for each Fuze Bench.
Setters (Assorted)........		6 ,, ,, ,,
Rasps, ½-round..........		3 ,, ,, ,,
Saws (Tenon)		2 ,, ,, ,,
,, Setters............		1 ,, Saw.
Files, 3-square		1 ,, ,,
Shell-Scrapers	25	3 for every 5 Mortars and Howitzers.
,, Hooks (Hand)	25	3 ,, 2 8-In. Mor. & Howitzers.
,, ,, (Beam)	18	3 ,, 2 10-Inch Mortars.
Cartouches, Wood.......	60	2 for each Gun.
,, Leather.....	105	1 ,, piece of Ordnance.

IMPLEMENTS AND STORES—*continued.*

IMPLEMENTS, ETC.	Number.	OBSERVATIONS.
Budge-Barrels	90	2 for each Mortar and Howitzer.
Hammers, Claw	105	1 ,, piece of Ordnance.
,, Sledge	21	1 for every 5 pieces of Ordnance.
,, Wrench	7	1 ,, 15 ,, ,,
Water-Buckets	107	3 ,, 2 ,, ,,
Crow-Bars	21	1 ,, 5 ,, ,,
Beams and Scales	6	1 ,, 5 Mortars.
Weights	6	1 Pile for each Pair of Scales.
Steelyards	7	1 for every 15 pieces of Ordnance
Adzes. . (Copper)		2 Sets for each Magazine.
Drivers ,,		
Vices ,,		
Can-Hooks ,,		
Capstans	3	
Blocks and Tackles		Complete for 3 Capstans.
Gyns, Triangle		2 for each Battery.
,, Gibraltar		
Blocks, Tackles, Falls, etc		Complete for the No. of Gyns.
Rope, Tarred, 4-Inch . . coils	6	
3 ,, ,,	6	
2 ,, ,,	6	
1 ,, ,,	20	
Rope, White, 6-Inch ,,	3	
4 ,, ,,	4	
3 ,, ,,	4	
2 ,, ,,	5	
Spunyarn ,,	15	1 for every 4 Guns.
Ratline ,,	15	1 ,, 4 ,,
Oakum or Junk cwt.	12	
Iron, Flat	15	¼ cwt. per Gun.
,, Square		
,, Rod		
,, Round		
,, Hooping		
,, Sheet	60	1 Sheet per Gun.
Steel, Sheer cwt.	1	1-15th the Quantity of Iron.
,, Blister		
Blacksmith's Tools		5 Sets for every 4 Smiths.
Coals		
Charcoal		
Lanterns, Muscovy		2 for each Battery, and ½ Spare.
,, Dark		
,, Tin		
Candles		

IMPLEMENTS AND STORES—*continued.*

IMPLEMENTS, ETC.	Number.	OBSERVATIONS.
Hand-Barrows		2 per Battery.
Wheel „	45	1 „ Mortar and Howitzer.
Spades	162	2 „ Gun, & Hy. Mor. & Howitzer.
Shovels	83	1 „ „ „ „
Felling Axes	26	1 for every 4 pieces of Ordnance.
Pickaxes	21	1 „ 5 „ „
Hatchets	26	1 „ 4 „ „
Hand-Bills	26	1 „ 4 „ „
Saws, Cross-Cut	11	1 „ 10 „ „
„ Hand	35	1 „ 3 „ „
„ Pit	6	1 „ 20 „ „
„ Setters	6	1 „ 7 Saws.
Mason's Levels		2 for each Battery.
Rammers, Earth		4 „ „
„ Paviours		2 „ „
Carpenter's Tools		5 Sets for every 4 Carpenters.
Nails, Spike		Sufficient to lay 3 Platforms for every 2 required, and further 2 months consumption for general purposes.
„ (of Sizes) Assorted		
Oak, Plank		
„ Skidding		
„ Sleepers		
Baulks, Pine		
Deals „		
Wadmiltilts		1 Set for each Magazine.
Tarpaulins		
Hair-Cloths		
Tanned Hides		
Shot Guages		1 Set for every 5 Guns.
Callipers pairs		1 for every 5 pieces of Ordnance.
Grates (for Heating Shot)		1 „ each Battery.
Fire-Irons and Shot-Bearers		1 Set for each Grate.
Laboratory Implements		
„ Stores & Materials		Vide Cartridge, Fuze, etc.
Collar-Maker's Tools		5 Sets for every 4 Collar-Makers.
Hides, Stout		2 Months' Consumption.
„ Light		
Bazils		
Thread, Hemp		
„ Dutch		
Twine		
Nails		
Tacks		
Buckles (Assorted)		
Bristles		

ART.

EMENTS AND STORES—*continued.*

PLEMENTS, ETC.	Number.	OBSERVATIONS.
es		2 Months' Consumption.
Black		
Bees'		
v		
eatsfoot		
er's Tools		5 Sets for every 4 Wheelers.
s ... pairs		1 for every 5 Carriages.
ets		1 ,, ,, 2 ,,
s		10 ,, each Carriage.
s		5 ,, ,, ,,
		1 ,, every 4-wheel Carriage.
ees (Wood)		1 ,, ,, 4 Carriages.
(Iron)		1 ,, ,, 3 ,,
Beds		1 ,, ,, 4 ,,
s, Large		1 ,, ,, 6 Garrison Carriages.
Small		1 ,, ,, 6 ,, ,,
Beds		1 ,, ,, 6 ,, ,,
s		1 ,, ,, 6 ,, ,,
ting Screws		1 for each Carriage.
rm Staples		1 Set for each Field Carriage.
s		
Spike		2 Months' Consumption for the Wheelers and Carpenters.
Clasp 40 py.		
30 ,,		
20 ,,		
10 ,,		
6 ,,		
Tacks		
ne Spikes	21	1 for every 5 pieces of Ordnance.
pins (Spare)		2 for each Carriage.
ions		5 for every 4 pieces of Ordnance.
Aprons		5 ,, ,, 4 ,, ,,
Lock Covers		5 ,, ,, 4 ,, ,,
zine Slippers		2 Sets for each Magazine.
Brooms, Long		
,, Short		
skins	90	2 for each Mortar and Howitzer.
ts, ½-Bushel	90	5 ,, ,, Heavy Mortar.
s		2 ,, ,, Platform.
urer's Tools		1 Set for each Armourer.
nith's ,,		1 ,, ,, Tinsmith.
r's ,,		1 ,, ,, Cooper.

Axletree.—*Carriage*,—***Wheel.***

Weight and Dimensions of Axletrees **for Field, Siege, and Transporting** Carriages.

ORDNANCE, ETC.	Weight of Gun.	Dimensions.						Weight of Axletree.
		Length of Bed.	Arms, etc.				Length of Axletree.	
			Diamtrs.		Length.			
	Cwt.		Shoulder.	Linch	Box.	Arm.		Cwt.
24-Pounder	50·0	3·125	·313	·229	1·667	1·709	6·542	1·822
10-Inch Howitzer......	40·0	3·125	·313	·229	1·667	1·709	6·542	1·822
Limbers..	..	3·334	·261	·178	1·167	1·375	6·125	1·018
18-Pounder	42·0	3·250	·292	·209	1·334	1·542	6·334	1·411
12 ,, ...	34·0	3·250	·292	·209	1·334	1·542	6·334	1·411
8-Inch Howitzer	20·0	3·334	·261	·178	1·167	1·375	6·125	1·018
Limbers ..	..	3·334	·261	·178	1·167	1·375	6·125	1·018
Waggons..	..	3·334	·261	·178	1·167	1·375	6·125	1·018
12-Pounder	18·0	3·584	·261	·178	1·167	1·323	6·375	1·018
Limbers ..	..	3·584	·261	·178	1·167	1·323	6·375	1·018
Waggons..	..	3·584	·261	·178	1·167	1·323	6·375	1·018
9-Pounder	13·5	3·584	·261	·178	1·167	1·323	6·375	1·018
6 ,, (Heavy)	12·0	3·584	·261	·178	1·167	1·323	6·375	1·018
24-Pounder Howitzer ..	13·5	3·584	·261	·178	1·167	1·323	6·375	1·018
6-Pounder (Light)	6·0	3·667	·229	·146	1·084	1·302	6·271	·768
3 ,, (Heavy)	6·0	3·667	·229	·146	1·084	1·302	6·271	·768
12-Pounder Howitzer ..	6·5	3·667	·229	·146	1·084	1·302	6·271	·768
Limbers.....	..	3·667	·229	·146	1·084	1·302	6·271	·768
Waggons....	..	3·667	·229	·146	1·084	1·302	6·271	·768
3-Pounder (Light).......	2·5	2·542	·167	·125	·917	1·063	4·667	·322
4⅖-Inch Howitzer.......	2·5	2·542	·167	·125	·917	1·063	4·667	·322
Limbers..	..	2·542	·167	·125	·917	1·063	4·667	·322
Carts	..	2·542	·167	·125	·917	1·063	4·667	·322
Devil-Carriages, Large..	..	4·188	·292	·209	1·334	1·542	7·271	1·634
,, Small.	..	3·667	·261	·178	1·167	1·375	6·459	1·125
Platform Waggons	..	3·667	·261	·178	1·167	1·396	6·459	1·027
Store ,, ...	..	3·667	·229	·146	1·084	1·302	6·271	·768
Forge ,, ...	..	3·667	·229	·146	1·084	1·302	6·271	·768
Flanders ,, ...	..	3·667	·229	·146	1·084	1·271	6·209	·608
Ball-Cartridge Waggons	..	3·667	·229	·146	1·084	1·302	6·271	·768
Store Carts	..	3·667	·229	·146	1·084	1·302	6·271	·768
Sling ,, ...	..	3·667	·292	·209	1·334	1·542	6·750	1·750
Hand ,, ...	..	3·167	·167	·125	·917	1·063	5·292	·322
Trench ,, ...	..	3·000	·229	·146	1·084	1·271	5·542	·608
Pontoon-Carriages	..	3·667	·229	·146	1·084	1·271	6·209	·608

Balls.—*Cartridge,*—*Lead, etc.*

General Table of Musquet, Carbine, etc. Balls.

SMALL-ARMS.	Calibre.	Number in a				Made from 1 Ton of Lead.
		Pound.		Cwt.		
	Inches.	Service.	Proof.	Service.	Proof.	No.
Musquet	·68	14.5	11·0	1624	1332	32,480
Carbine, Rifle Bore ..	·60	20·0	17·0	2240	1904	44,800
„ Musquet „	·68	14·5	11·0	1624	1332	32,480
„ Pattern 1838.	·68	14·5	11·0	1624	1332	32,480
Rifle.................	·60	20·0	17·0	2240	1904	32,480
„ Pattern 1838....	·68	13·5		1512		30,240
Pistol, Musquet Bore.	.68	14·5	11·0	1624	1332	32,480
Rifle	·60	20·0	17·0	2240	1904	44,800

About 1 lb. of lead in 28 is lost in casting. The balls are packed in boxes, each containing 1 cwt.

In casting the balls, the only points requiring particular attention, are:—

1. That the lead be not raised to too high a degree of heat, but only to such a state of fluidity as will allow of its running freely into the moulds, and,

2. That the moulds be dipped in water to cool them, after every dozen casts.

Should these precautions be neglected, the balls will not be solid.

The implements required, are:—

Melting Pots ..	1	Moulds	2
Ladles	2	Nipping Engines..	1
Plyers, pairs ..	1	Water Tubs	1

Shot Boxes..4

With these implements, 2 men can cast about 1 ton of lead in a day, and 2 experienced boys will nip 2 cwt. of balls—one of them taking the instrument in the morning, the other in the afternoon. The day is reckoned at 10 working hours.

Weight and Dimensions of Leaden Balls.

The weights and dimensions of these balls may be computed by means of their specific gravities, but still more readily by the following rules:—

1. *To find the Weight of a Ball, its Diameter being known.*

A leaden ball of 1 inch diameter weighs $\frac{3}{14}$ of a pound; therefore—

As the cube of 1 is to $\frac{3}{14}$, or, as 14 is to 3, so is the cube of the diameter of any other ball to its weight.

The diameter of a ball being 6·6 inches, required its weight?

$$\text{Here, } 14 : 3 :: 28{\cdot}7496 : 61{\cdot}607 \text{ lbs.}$$

The diameter of a ball being $\frac{1}{40}$ of an inch, required the number that can be made from 10 lbs. of lead?

$$\text{Here, } 14 : 3 :: \left(\frac{1}{40}\right)^3 : \frac{3}{896000} \text{ lbs.}$$

$$\text{And, } 3 : 896000 :: 10 : 2986667 \text{ Balls.}$$

2. *To find the Diameter of a Ball, its Weight being known.*

Multiply the given weight by 14, and take the cube root of $\frac{1}{3}$ of the product for the diameter.

The weight of a ball being 64 lbs., required its diameter?

$$\text{Here, } \left(\frac{64 \times 14}{3}\right)^{\frac{1}{3}} = (298{\cdot}67)^{\frac{1}{3}} = 6{\cdot}684 \text{ inches.}$$

Barrels.—*Bridges, etc.*

Weight and Dimensions of Powder Barrels, Filled and Empty.

BARRELS.	Length.	Diameters.		Weights.		Content.
		Head.	Bulge.	Empty.	Filled.	
Watertight, Whole	1·750	1·250	1·459	35·25	115·25	80·0
„ Half	1·417	1·000	1·083	23·82	63·82	40·0
Whole, Copper-Hooped ..	1·792	1·292	1·438	27·00	117·00	90·0
„ Hazle „ ..	1·792	1·292	1·438	18·25	108·25	90·0
Half, Copper-Hooped	1·437	1·020	1·167	17·25	62·25	45·0
„ Hazle „	1·437	1·020	1·167	11·50	56·50	45·0
Quarter, Copper-Hooped..	1·084	·792	·895	10·50	33·00	22·5
„ Hazle „ ..	1·084	·792	·895	7·62	30·12	22·5
Bulge, Copper-Hooped ...	·875	·959	1·084	10·00	48·00	38·0
„ Hazle „ ...	·875	·959	1·084	16·00	44·00	38·0

The contents given above are only nine-tenths of the actual quantity that each barrel will contain. The odd tenth is omitted that the powder may be shaken, which tends much to its preservation in store.

Contents and Capacities of Casks.

It is usual, when great accuracy is required, to divide the casks into classes according to their greater or less degree of bulge, and to compute the bulk or capacity of each by a separate rule. To enter into these minutiæ in a work of this description, would occupy more space than the importance of the subject would justify;—the more especially as the following general rules are sufficiently accurate for all practical purposes.

1. *To find the Magnitude or Bulk of a Cask.*

Multiply twice the area at the bung plus the area of the head, by the length, and take one-third of the product for the bulk or magnitude. That is—

$$(2.\ D^2 + d^2) \times \tfrac{1}{3}\,Ln = C.—$$

D, d, diameters at the bung and head;—n, ·7854;—L, length of the cask;—and C, its bulk or magnitude.

The length of a cask being 4 feet, and the head and bung diameters 26 and 33 inches respectively, required its bulk or magnitude?

$$\text{Here, } (2.\ D^2 + d^2) \times \tfrac{1}{3}Ln = 35864{\cdot}5056 = 20{\cdot}755 \text{ Cubic feet.}$$

2. *To find the Content or Capacity of a Cask.*

Compute the bulk in cubic inches, by the preceding rule (using the interior dimensions of the cask), and divide by 277·25 for the content or capacity in gallons. That is—

$$\frac{(2.\ D^2 + d^2) \times \tfrac{1}{3}Ln}{277{\cdot}25} = C.—$$

The interior length of a cask being 45 inches, and the head and bung diameters 24 and 30 inches respectively, required its content or capacity?

$$\text{Here, } \frac{(2.\ D^2 + d^2) \times \tfrac{1}{3}Ln}{277{\cdot}25} = \frac{29428{\cdot}938}{277{\cdot}25} = 106{\cdot}15 \text{ Gallons.}$$

3. *To find the Buoyancy of a Cask.*

Multiply the bulk by the specific gravity of water, and from the product subtract the weight of the cask. The remainder will be its buoyancy, or the weight which it will support without sinking—That is,

$$\left(G.\,(\overline{2.\ D^2 + d^2} \times \tfrac{1}{3}\,Ln)\right) - W = B.—$$

G, specific gravity of water;—W, the weight of the cask;—and B, its buoyancy.

The head and bung diameters of a cask being respectively 1·25 and 1·45 feet; its length 1·75 feet, and its weight 35·25 lbs., required the weight it will support without sinking?

$$\text{Here, } \left(G.\,(\overline{2.\ D^2 + d^2} \times \tfrac{1}{3}\,Ln)\right) - W = 2109{\cdot}1816 = 131{\cdot}3863 \text{ lbs.}$$

Baskets.—*Artillery,—Bomb Vessels,—Mines, etc.*

Ballast ½ bushel	Weight 5 lbs.
Depth 1 foot	Diameter 1 foot 6 inches.

Battery.—*Artillery,—Fortification,—Platform, etc.*

Batteries receive different denominations according to the nature of the ordnance mounted in them;—their localities;—and the positions which they occupy with reference to the objects against which they are directed.

Gun Batteries.

The Length of the Epaulment depends upon the number of guns which the battery is to contain:—

Epaulment,—		
Length, for 1 Gun	18·000	15·000
Interior height............	7·000	7·000
Exterior „	6·334	6·334
Thickness at top	18·000	15·000
„ „ bottom	25·000	20·000
Base of Interior Slope	2·000	2·000
„ Exterior „	5·000	3·000
Berm,—		
Breadth..................	3·000	2·000
Ditch,—		
Depth	8·000	8·000
Breadth at top	17·500	14·834
„ „ bottom	8·500	7·000
„ of Interior Slope ..	4·000	3·000
„ „ Exterior „ ..	5·000	4·000
Embrazures,—		
Width of Interior Opening ..	1·667	1·667
„ „ Exterior „ ...	9·000	7·506
Height of the Sole	2·667	2·667
Slope „ „	1·500	1·334
Cubic feet of earth, for 1 Gun ...	2157·000	1457·000

The first of these profiles is calculated for the worst description of soil,—the second, for earth of greater tenacity, or for batteries in confined situations.

Howitzer Batteries.

Howitzer batteries, with the exception of the embrazures, have precisely the same dimensions as gu batteries:—The interior openings of the embrazure of howitzer batteries are made 2 feet 6 inches wid and the soles are countersloped inwards, at an angl of about 10 degrees.

Observation.—If the situation of a battery wi admit of its being sunk, so that the soles of the em brazures may coincide with the level of the ground, great advantage will be gained, and much time an labour saved in its construction. In batteries witho embrazures, this method may almost always be adopte and in some situations it is absolutely necessary, i order to obtain the earth required to form the epau ment. When a battery, for example, is to be co structed on the crest of the glacis, or on the edge of th counterscarp, there can be no excavation except to th rear.

Mortar Batteries.

Mortar batteries, having no embrazures, requi larger quantities of earth for the formation of th epaulments, than gun or howitzer batteries. T obtain these additional quantities therefore, 2 fe must be added to the breadth of the ditch of mortar battery over and above the dimensions est blished for a gun, or howitzer battery having embr zures. These dimensions,—the mortars being plac at the same distances apart as the guns or howitzers will give for the first profile 2457 cubic feet of ear and for the second profile 1738 cubic feet per morta

If the mortars be placed at the undermentioned distances from the foot of the epaulment, they may be fired at the corresponding angles of elevation.

10 Feet	....45 Degrees.	19 Feet	....20 Degrees.
12 „	....35 „	30 „	....15 „
14 „	....30 „	56 „	....10 „
17 „	....25 „	80 „	.... 5 „

Barbette Batteries.

When the guns are not to act against any particular point,—when the enemy can attack in any direction,—or when the battery is situated on higher ground than any which he can possibly occupy, so that the greater part of his shot must pass above it, the guns should fire en-barbette—that is to say, over the epaulment. Mounds of earth must therefore be raised, in rear of the epaulments, to a height just sufficient to allow the muzzles of the guns to be run over their crests; or, when a battery is to be sunk, these mounds must be marked out before breaking ground, and the earth to form the barbette, left undisturbed.

Coast Batteries.

Coast batteries generally consist of a simple epaulment, without much attention to the dimensions of the ditch. They sometimes have embrazures, but more generally the guns are mounted on traversing platforms, and in this case, they fire over the epaulment.

Military writers in general prefer low situations for these batteries. M. de Gribauvale says, the height of a battery of this description above the level of the sea, must depend upon its distance from the principal objects that it has to protect, or annoy; and that the shot, to ricochet with effect, should strike the water at an angle of about 4 or 5 degrees at the distance of 200

[illegible]

[illegible]

[illegible]

[illegible] and [illegible]

[illegible]

rear of the latter, at which it is intended that the men, on the terre-plein, should be covered from the enemy's fire. These two points being ascertained, the proper height may be determined by a simple calculation, or practically by the following easy process:—

The horizontal breadths of the several slopes being traced upon the ground, let a man place himself upon the line over which the crest is supposed to pass, and there erect a long staff:—at the same time let a second man, provided with a staff 6 feet long, place himself in line with the former, and the object, and as far in the rear of the intended crest, as it is desired that the ground should be defiladed, or placed under cover from the enemy's fire, and there erect his staff. Then placing his eye on a level with the top of it, he must observe where the line of sight passing over the hostile object, cuts the first staff. The point of intersection thus obtained, marks the proper height to be given to the epaulment.

The epaulment being constructed with the materials procured from the excavation of the ditch, it follows that the solid content of the one, must be just equal to that of the other. Therefore, to determine the breadth of the ditch, divide the superficial content of a vertical section of the epaulment by its proposed depth; the quotient will be the mean breadth, to which add half the sum of the horizontal breadths of the two slopes for the breadth at top, and subtract the said half sum for the breadth at bottom.

Blue-Lights.—*Composition*, *etc.*

Blue-Lights are fixed in hand-cases of well-seasoned alder, of nearly the same dimensions as a 10-inch fuze; the cups of the cases being rather more capacious.

yards. The distance, therefore, of the object, must be the radius, and the height of the battery the tangent of the angle of impetus, which, on the above supposition, will be about 14 yards measured from high-water mark.

In the foregoing observations, the battery and the point against which it is directed, are supposed to be in the same horizontal plane. There are two contingencies however to be considered,—each of which requires that the height of the epaulment, and the dimensions of the ditch, should be increased or diminished, according to the following principles.

It is manifest when the battery commands the object, that the height of the epaulment need not be so great as when the battery and object are situated in the same horizontal plane, for in this case the line of fire from the lower situation can never approach nearer to the heads of the men on the terre-plein of the battery, than the crest of the epaulment. The epaulment may therefore be lowered in proportion as the command of the battery increases, provided it is never made less than 6 feet.

When the object commands the battery, the line of fire approaches constantly nearer and nearer to the heads of the men stationed behind the epaulment, and, in the same proportion, as the command of the object increases, will the distance from the foot of the epaulment diminish, at which a shot from the enemy will strike the terre-plein of the battery. Here, therefore, it is evident, that the height of the epaulment must be increased, directly, in proportion to the command of the object, and inversely, in proportion to its horizontal distance from the battery. Therefore,—

To determine the height to be given to an epaulment, it is necessary to know the horizontal distance from the object to the battery, and the distance, in the rear of the latter, at which it is intended that the men, on the terre-plein, should be covered from the enemy's fire. These two points being ascertained, the proper height may be determined by a simple calculation, or practically by the following easy process:—

The horizontal breadths of the several slopes being traced upon the ground, let a man place himself upon the line over which the crest is supposed to pass, and there erect a long staff:—at the same time let a second man, provided with a staff 6 feet long, place himself in line with the former, and the object, and as far in the rear of the intended crest, as it is desired that the ground should be defiladed, or placed under cover from the enemy's fire, and there erect his staff. Then placing his eye on a level with the top of it, he must observe where the line of sight passing over the hostile object, cuts the first staff. The point of intersection thus obtained, marks the proper height to be given to the epaulment.

The epaulment being constructed with the materials procured from the excavation of the ditch, it follows that the solid content of the one, must be just equal to that of the other. Therefore, to determine the breadth of the ditch, divide the superficial content of a vertical section of the epaulment by its proposed depth; the quotient will be the mean breadth, to which add half the sum of the horizontal breadths of the two slopes for the breadth at top, and subtract the said half sum for the breadth at bottom.

Blue-Lights.—*Composition*, *etc.*

Blue-Lights are fixed in hand-cases of well-seasoned alder, of nearly the same dimensions as a 10-inch fuze; the cups of the cases being rather more capacious.

Materials required to Complete 100 Blue-Lights.

Saltpetre	9·625 lbs.	Packthread	·250 lbs.
Sulphur	2·406 „	Dutch Twine	·062 „
Red Orpiment	·687 „	CartridgePaper	10·500 sheets.
Quick-match	·094 „	Brown „	17·000 „
Paste	2·000 „	S. A. Packing	18·000 „

Alder Poles, 2·75 inches in diameter...60 feet.

Bomb-Vessels.—*Mortar, etc.*

Bomb-Vessels were first employed by the French in 1681, at the bombardment of Algiers. The earliest mention of them in this country bears the date of 1688, but upon what particular service they were then employed does not appear.

The detachment of marine artillery required for the service of the mortars, usually consists of a lieutenant, serjeant, corporal, bombardier, and ten gunners.

Instructions for their Management and Security in Action.

The mortars, mounted on their beds in the midships of the gun-deck, traverse on circular platforms. They may be fired over either side of the ship, but never at lower angles than 45 degrees. When at sea they should be lashed down to their platforms, the bolsters being first removed to allow them to rest upon the bed-transoms.

Before the tarpaulins and mortar-hatches are removed, the booms must be wetted: — this being done, an explosion bulk-head of 3-inch plank must be fixed between the mortars and the after part of the vessel. The magazine and filling-room must also be secured by means of tarpaulins nailed round the after hatch-way; and, before firing, the doors of the bulk-heads under the quarter-deck must be shut, that the cabins may not be injured by the explosion.

A non-commissioned officer and 2 gunners should be told off to the filling-room to measure out the charges, and fix the shells,—another non-commissioned officer and 3 gunners, for the service of each mortar, and a gunner to receive on deck the 13-inch shells, and lower them into the mortars. That a constant fire may be kept up, and from 45 to 50 shells be thrown in an hour, these men will require to be assisted in their several duties, by a detachment of the crew,—namely, 8 men in the shell-room and cock-pit to get out the empty shells, and whip them up when loaded; 1 man to serve each mortar with powder, and supply the artillery-men, fixing the shells, with fuzes; and 6 men on the quarter-deck, to whip the 13-inch shells into the mortars.

The fuzes should be cut by a non-commissioned officer or steady gunner under the officer's immediate superintendence. The forecastle is the most convenient place for these operations, as the officer can there readily make any alterations he may require, without being obliged to send his orders, which are always liable to mistake, to the filling-room. The officer, standing on the quarter-deck, should himself lay the mortars, with a plummet in the usual manner.

The whole of the shells should be hoisted on deck by means of a pulley or whip, and the 13-inch shells lowered into the mortar by means of a second whip made fast to the mainstay directly over its mouth. The 10-inch shells may be readily carried along the gang-way by 2 men with a shell-beam, and lowered into the mortar by hand.

In taking up their stations in order to a bombardment, it is desirable that the vessels should keep without the range of the enemy's batteries, or at a distance of 3,000 yards from them, and that they should have springs upon their cables.

Composition of an Armament for a Bomb-Vessel.

ORDNANCE, ETC.	Number.	OBSERVATIONS.
ORDNANCE.		
Mortars 13-Inch	1	
10 ,,	1	A Bomb-Vessel on the blishment carried 2— Mortars, 4—68, and Pounder Carronades.
Guns, 6-Pounder	2	
Carronades 24-Pounder	8	
12 ,,	1	
CARRIAGES.		
Mortar Beds 13-Inch	1	Complete with Pintails, et
10 ,,	1	,, ,, ,, ,,
Gun, 6-Pounder	2	,, ,, Stool-Beds
Carronade 24-Pounder	8	,, ,, Elevating
12 ,,	1	,, ,, ,,
Breechings 4⅖-Inch	3	For the Guns.
5⅓ ,,	2	,, ,, 12-Pounder Carro
6⅓ ,,	12	,, ,, 24 ,,
Tackles 2-Inch	24	For the Carronades.
1⅓ ,,	3	,, ,, Guns.
SPARE ARTICLES.		
Pintails	1	
Cap-Squares	2	
Keys and Chains	4	
Bolts, Traversing	4	
,, Dog	4	
Wedges and Blocks ......sets	1	
Quoins, Mortar	2	
,, Gun	1	
,, Carronade	8	
Stool-Beds	1	
Trucks, Fore	2	
Axletrees, Hind	1	
Eye-Pins and Chains	2	
Washers	4	
Linchpins	4	

DETAIL of a PROPORTION of AMMUNITION, ETC. *for a* Bomb-Vessel.

AMMUNITION, ETC.			Number.	OBSERVATIONS.
Shells	Mortar	13-Inch	400	
		10 ,,	400	
	Hand, Fixed		210	
Carcases	13-Inch, Fixed		40	
	10 ,, ,,		40	
Valenciennes Composition			600	300 Proportions per Mortar.
Shot	Round	24-Pounder	720	
		12 ,,	90	
		6 ,,	180	
	Grape	24-Pounder	57	
		12 ,,	7	The service charge of the 13-Inch Mortar is 20; of the 10-Inch, 9·5 lbs.
		6 ,,	14	
	Case	24-Pounder	56	
		12 ,,	20	
		6 ,,	14	
	Pound		5000	
Wood Bottoms			80	For Carcases and ℔ Shot.
Gunpowder	Barrels	Whole		Calculated at the Full Charge, Bursting Powder included.
		Half	44	For the Guns and Carronades.
	Mealed lbs.		90	
Cartridges	24-Pounder		833	
	12 ,,		117	
	6 ,,		208	
Fuzes, Empty			1000	500 for each Mortar.
,, Composition lbs.			138	
Portfires			200	The Shells, Carcases, Powder, and Fuzes, are the only stores which have particular places fitted up for their reception. The Shells, empty, are stowed in lockers, called shell-rooms, in the fore and after holds. The Carcases are secured in separate cases, on shelves, in a frame-work directly under the mortars, and the Powder and Composition in the Magazines. The Fuzes and small-stores are arranged in cases ready for use, in the filling and store-rooms.
Tubes, Tin			440	
,, Quill			840	
Paper, 6-Pounder Cartridge, qrs.			10	
,, Brown ,,			6	
Cotton Wick lbs.			4	
Alcohol galls.			8	
Slow-match cwt.			1	
Quick-match, Lengths			1000	
,, Pounds			20	
Rockets, 1 lb. Signal			6	
,, ½ ,, ,,			18	
Blue-Lights			36	
Coarse Twine lbs.			4	
Junk cwt.			15	
Flints			600	

IMPLEMENTS, STORES, ETC. for a Bomb-Vessel.

IMPLEMENTS, ETC.	Number.	OBSERVATIONS.
Spunges, Common	15	2 per Mortar; 1 per Gun and Car
„ Rope	2	1 for each 6-Pounder.
„ Heads, Common	3	1 for every 3 Carronades.
„ „ Rope	1	1 „ „ 2 Guns.
„ Caps	13	1 for each Gun and Carronade S
„ Combs	2	
„ Staves	2	
Wadhooks	3	1 for 2 Guns; 2 for 9 Carronade
Ladles		
Funnels, for Shells	2	1 for each Mortar.
„ „ Loading	2	1 „ „ „
Quadrants	1	
Plummets (Lead)	3	For the 2 Mortars.
Handspikes, Common	4	
„ Mortar	6	
Traversing Bars	9	1 for each Carronade.
Dutch Pumps	2	1 „ „ Mortar.
Claw-Hammers	2	
Tompions	44	4 for each Gun and Carronade.
Tube-Boxes	4	
Portfire-Sticks	4	
Lintstocks	4	
Gun-locks	13	1 for each piece of Ordnance.
Powder Measures....sets	1	1 „ the 2—6-Pounders.
„ Horns	18	
Fuze-Benches	1	
„ Knives (Block)	1	
„ Engines	1	
„ Blocks	2	1,—13, and 10-Inch Socket in ea
„ Mallets	24	12 for each nature of Fuze.
„ Drifts (Driving)	8	4 „ „ „ „
„ Ladles	4	2 „ „ „ „
Saws, Tenon	4	
„ Setters	1	
Rasps, ½-round	6	
Files, 3-square	8	
Spoke Shaves	1	
Compasses ....pairs	2	
Diagonal Scales	1	
Corkscrews	2	
Mallets	8	
Setters	16	
Ragstones	2	
Salting-Boxes (Copper)	2	

BOM.

IMPLEMENTS, STORES, ETC.—*continued.*

IMPLEMENTS, ETC.	Number.	OBSERVATIONS.
Priming Irons ....sets	36	
Vent-Bits	5	
Lead Aprons	13	1 for each pieoe of Ordnance.
„ Lock Covers	11	1 „ „ Gun and Carronade.
Marline Spikes	3	
„ Skeins	12	
Cartouches	22	2 for each Gun and Carronade.
Barrels — Budge	2	
Barrels — Common — Whole ...	31	
Barrels — Common — Half	44	
Barrels — Common — Quarter ..	1	
Barrels — Water-tight	4	
Adzes........(Copper)........	2	
Drivers „	4	
Vices „	2	
Snuffers „ ....pairs	2	
Can-Hooks „ .... „	2	
Forelock Keys „ .... „	3	
Funnels „ .... „	1	
Shovels „ .... „	1	
Slices, Copper	1	
„ Wood	2	
Mealing Tables	1	
„ Rubbers	1	
Brushes, Hand	1	
Sieves and Covers	1	
Boxes, Composition	2	
„ Priming	1	
„ Ammunition	120	
Tubs, Composition....	2	
Tube-Prickers (Brass)	2	
Beams and Scales ....pairs	1	
Weights ....sets	1	4 lb. piles.
Hair Cloths	2	
Hides (Tanned)	6	
Buckets (Leather)	6	
„ (Wood)		
Laboratory Chests	1	
Handscrews, Long	1	
„ Short	1	
Crowbars, 4 feet 6 inches	4	
Handscrew Levers, 6 feet	4	
„ „ 3 „	4	
Hatchets, Hand	2	

IMPLEMENTS, STORES, ETC.—*continued.*

IMPLEMENTS, ETC.	Number.	OBSERVATIONS.
Lifting Tongs	2	1 pair for each Mortar.
Shell-Scrapers	4	
Purchase Chisels	4	
Wad-Guages	4	1 for 2 Guns; 3 for 9 Carron
Lanterns, Muscovy	2	
„ Dark	2	
„ Tin	1	
Tackles and Blocks	10	4,—2½ and 6,—2-Inch.
Blocks, Single .. sets	4	
Tackle-Hooks, Large pairs	11	
„ „ Small „	4	
Rope, White 3-Inch fathoms	40	
„ Tarred 2- „ „	40	
Sheepskins	6	
Brooms, Magazine	1	
Slippers „ sets	2	
Tallow lbs.	56	
Melting Ladles	1	
Soft Soap lbs.	64	
Powder Bags	9	
Baskets, ½-bushel	8	
Nails, 20-penny	100	
„ 10 „	200	
„ 6 „	300	
Pincers, Fuze pairs	3	
„ Common „	3	
Charcoal bush.	6	
Glue lbs.	5	
„ Brushes	4	
„ Kettles	2	
Kitt lbs.	80	
„ Brushes	6	
„ Kettles	1	
„ „ Trivets	1	
Canvas yards	62	
Line, 18-Pounder lbs.	2	
Augers, Common	2	
Cutting Knives	4	
Scissors pairs	2	
Needles	24	
Armourer's Tools sets	1	Vide Artificer's Tools.
Books, Supply	1	
„ Expense	1	
Abstracts	24	

Breach.—*Artillery,—Fortification,—Vent.*

The first operation of the batteries must be, to strike out, by a horizontal line, the extent of the proposed breach, and their whole efforts must then be directed towards deepening this cut, and gradually opening two others vertically from its extremities. The portion of the revetment thus outlined, should it not be overthrown by the pressure of the earth behind, must be finally detached from the adjoining parts, by the discharge of a few salvoes against its centre, which will speedily bring it down in a mass.

If the ditch be dry, the horizontal cut above mentioned should be struck at about six feet from the foot of the revetment,—if wet, close to the water's edge; and it is important to observe that the instant the wall is down, and the parapet destroyed, the breach is as perfect, and the slope as easy, as it can be made by the fire of the batteries.

It would appear by the practice, at the sieges of Cuidad Rodrigo, Badajos, and St. Sebastian, that a breach of considerable extent may, with a given number of guns, be formed by one, or at most by two, days firing.

Cuidad Rodrigo was attacked on the 8th, and the batteries opened their fire on the 14th January, 1812. At this siege, 9,515 round shot were expended in 32½ hours, and two breaches were formed,—the one 30, and the other 100 feet wide,—from a distance of between 500 and 560 yards. The hourly expenditure of ammunition was consequently 292·76 rounds in battering, or otherwise.

If we suppose therefore only 3 hours firing, or 878·28 rounds to have been given to the defences, there will remain 8,636·72 to be distributed between the two breaches;—namely, 1,993·09 to the lesser, and 6,643·63 to the greater breach.—Had therefore 40—24-pounders been employed on the great breach, with this expenditure of ammunition, or 166·09 rounds per gun, it is evident that it would have been formed, and rendered practicable, in 8½ hours, the period of day-light, or by one day's firing.

Badajos was invested on the 16th, and the batteries opened on the 30th March, 1812. The time of firing was 104 hours, and 23,896 round shot are supposed to have been expended in effecting three breaches of 40, 90, and 150 feet in width respectively, from a distance of between 600 and 700 yards.

The breach in the curtain, 40 feet wide, was formed in 13 hours by 14 guns, at an expenditure of 3,514 rounds of ammunition. Consequently 20,382 rounds were expended on the other two breaches, namely, 7643·25 on the breach in the flank, which was 90 feet wide, and 12,738·75 on that in the face of the bastion, which was 150 feet wide. It would appear therefore that had 50—24-pounders been put in battery to breach the face of the bastion, with a proportionate expenditure of ammunition, or 254·78 rounds per gun, even this breach would have been formed and rendered practicable in 13 hours, or by one day's firing.

St. Sebastian was attacked on the 11th, and the batteries opened their fire on the 20th July, 1813. The time of firing—first part of the siege—was 62 hours, or, four days of 15½ hours each; 20—24-pounders were employed, and two breaches, the one 30, and the other 100 feet wide, were formed from a distance of about 600 yards. One day's firing was devoted to the small breach, two days and a half to the great breach, and half a day's to the defences.

Hence, had 50, instead of 20,—24-pounders been placed in battery, at this siege, it is manifest that both breaches would have been formed, and rendered practicable by less than one day's firing.

Bridge.—*Barrel,—Pontoon,—Cable.*

Military bridges usually consist of pontoons, or other floating bodies connected together by a superstructure of baulks and chesses,—strength and buoyancy are therefore the essential points to be attended to in the construction of such a bridge.

On the first point, ample information will be found under the head Materials. The general principles of the latter, are comprised in the following observations,—

On the Buoyancy of Bodies.

If a body be immersed, or partly immersed, in a fluid, it will displace a bulk of the fluid equal in magnitude to itself, or to that part of it, which is immersed. And as, before the immersion, the pressure downwards upon the fluid immediately below the place subsequently occupied by the body, is equal to the weight of the fluid displaced by the immersion, that weight will be the measure of the upward reaction of the fluid below the body,—or, the measure of the force, by which its descent will be impeded;—otherwise the fluid would not be in equilibrium both before, and after the immersion.

If therefore a body be entirely immersed in a fluid of the same specific gravity as itself, it will remain at rest in what situation soever it may be placed: because, in this case, the upward reaction of the fluid will be just equal to the downward pressure of the body, and the body may be said to have lost all its weight by the immersion. And if the specific gravity of the body, be greater than that of the fluid, the body will sink; because here the downward pressure, will be greater than the upward reaction, and the body may be said to have lost just so much of its weight, as is equal to the bulk of the fluid displaced.

Again, if the specific gravity of the body be less than that of the fluid, the body will float; because in this case, the upward reaction, will be greater than the downward pressure. The body will however sink to a depth at which its downward pressure will be equal to the upward reaction of the fluid, or until the pressure and reaction are in equilibrio. Hence, when a body floats, it displaces just so much of the fluid as is equal in weight, to the weight of the body.

ON THE SITUATION OF THE BRIDGE.

The choice of the point at which to effect the passage of a river, involves many important, and apparently contradictory considerations.—If the passage is to be forced in the presence of an enemy, the concave or re-entering sinuosities of the stream, are usually selected as the most advantageous; because, in such a situation, not only will the batteries intended to support the construction of the bridge, and protect the passage of the troops, be posted so as to cross their fire over the position of the enemy on the opposite bank, and take the approaches to the bridge in reverse, but, the passage being effected, the ground gained on the opposite shore, will afford the best possible site on which to erect the works required to cover the head of the bridge. Further, the water is invariably deeper, and the banks higher in the concave bends than in any other part of the river; the bank to which the passage is to be attempted therefore, will, in such situations, be commanded by that from which it is to be made.

If the establishment of a communication only, without immediate reference to offensive, or defensive operations is the object to be attained, the concave bends are liable to the objection, that, in those parts, the force of the current is unequal, and consequently acts very injuriously on the floats, or piers of the bridge. For the mere purposes of communication therefore, situations between the bends are usually selected, as less subject to sudden changes, and inequalities in the current; and consequently also more free from deposits of mud, and slime.

Bridges of communication between the quarters of an army, or different parts of the attack at a siege, should if possible, be placed above the town: otherwise, the enemy may destroy them by taking advantage of the current, to float down trees or other heavy bodies. It is also necessary in these situations, that two bridges should be established side by side, to prevent the confusion consequent upon an endeavour to cross, and recross upon the same bridge.

It is of the utmost importance under all contingencies, that situations should be chosen where the banks are not too low, and where the anchorage is good, and secure; that small islands, where met with, should be made available, and above all, that advantage should be taken of bays and inlets, or tributary streams, in which the boats or pontoons may be launched, out of view of the enemy, and floated down with the current to the intended point of passage.

On the Construction of Military Bridges.

The breadth of the river, and the rapidity of its current being ascertained, the first point to be considered in the construction of the bridge is the weight which it may be required to sustain.

Infantry, formed in two ranks, occupy 3 feet in depth. A horse, standing at picket, occupies 27 superficial feet, or 3 feet in breadth, and 9 in depth. A field gun, or ammunition waggon, limbered up, with four horses, covers 148·5 feet, superficial measure, or 4·5 feet in breadth, and 33 in depth. The bearing points of the gun and limber wheels are 9 feet apart; and each additional pair of horses occupy a further lineal space of 12 feet.

An infantry soldier, with his arms, ammunition, accoutrements, etc., weighs on an average about 198 lbs. A cavalry soldier, about 265, and his horse 1036 lbs. The average weight of a piece of field artillery, gunners not included, horsed and equipped for service, is—

18 Pounders	19,000 lbs.	6-Pounders	(heavy)	13,459 lbs.
12 "	14,259 "	6 "	(light)	9,076 "
9 "	13,674 "	3 "	(heavy)	9,022 "

The available buoyancy of every 60 feet lineal of the bridge should therefore be,—with

Infantry (120 men) formed four deep,	21,360 lbs.
Cavalry (12 men) in file	15,621 "
Artillery, 12-Pounders	14,259 "

By which it would appear that a bridge calculated for the passage of infantry, formed four deep, may, with safety, be passed by cavalry, in file, or by a field battery in column of route.

Every possible precaution must be taken to preserve the bridge from injury. Infantry should therefore never be allowed to pass at the same time with cavalry or artillery. In the passage of cavalry, the men should dismount, and lead their horses, and even then, only two or three should march abreast. Under no circumstances should a horseman be permitted to pass at a trot. Artillery and other carriages should cross in succession, and at certain distances apart. This precaution is absolutely necessary to prevent the overloading of the bridge, and, for the same reason, two carriages should never be permitted to meet upon it.

The greatest possible care is requisite in the passage of large droves of cattle. Bullocks naturally crowd together in a mass, and are very likely to swamp a bridge of light boats. To guard against this danger, a few only, carefully driven, should be allowed to pass at the same time.

ABLE.—*Cordage,—Hawser,—Rope.*
Weight and Dimensions, etc. of Cables.

MANUFACTURE, ETC. *Machine* ***Made.)***

FATHOMS.	9-INCH. (432 Thds.)		10-INCH. (504 Thds.)		11-INCH. (612 Thds.)		12-INCH. (756 Thds.)	
	Weight.	Strength.	Weight.	Strength.	Weight.	Strength.	Weight.	Strength.
1	17	36,288	19	44,800	24	54,208	29	64,512
2	34		39		48		59	
3	51		59		72		89	
4	68		79		96		119	
5	85		99		121		149	
6	102		119		145		179	
7	119		139		169		209	
8	136		159		193		239	
9	153		179		218		269	
10	171		199		242		290	
11	188		218		266		328	
12	204		238		290		358	
13	221		258		314		388	
14	238		278		338		418	
15	256		299		363		448	
16	272		318		386		478	
17	290		338		412		508	
18	306		358		436		538	
19	323		378		460		568	
20	342		399		484		598	
25	427		498		605		752	
30	512		598		727		898	
35	599		688		848		1047	
40	684		798		969		1197	
45	769		898		1090		1347	
50	855		998		1211		1497	
55	940		1041		1327		1631	
60	1026		1197		1454		1796	
65	1111		1297		1576		1945	
70	1197		1397		1696		2095	
75	1282		1497		1813		2245	
80	1368		1596		1939		2395	
85	1453		1696		2060		2488	
90	1539		1796		2181		2694	
95	1568		1896		2302		2844	
100	1710		1996		2433		2994	
101	1728		2016		2468		3024	

Calibre.—*Gun,—Howitzer,—Carronade.*

Calibres of English and Foreign Guns in English Inches.

ORDNANCE.	English.	Austrian.	Danish.	Dutch.	French.	Prussian.	Russian.
Guns.							
10-Inch	10·000	..	..	..	..	..	..
68-Pounder	8·050	..	..	..	..	..	..
36 ,, ...	..	..	6·887	..	6·883	..	6·837
32 ,, ...	6·410 6·350 6·300	..	..	..	..	..	..
30 ,, ...	..	..	..	..	6·483	..	6·433
24 ,, ...	5·823	5·911	6·016	5·973	6·010	5·869	5·972
18 ,, ...	5·292 5·170	5·370	5·467	5·405	5·461	..	5·417
16 ,, ...	..	..	..	..	5·262	..	..
12 ,, ...	4·623	4·962	4·775	4·719	4·778	4·675	4·740
9 ,, ...	4·200	..	..	..	..	..	..
8 ,, ...	..	..	..	..	4·174	..	..
6 ,, ...	3·668	3·723	3·790	3·754	3·774	3·706	3·762
4 ,, ...	..	..	..	..	3·315	..	..
3 ,, ...	2·913	2·955	3·000	3·960	..	2·945	2·986
Howitzers.							
10-Inch	10·000	..	..	..	..	..	..
8 ,, ...	8·000	..	..	..	8·779	..	..
40-Pounder	..	..	..	..	..	..	7·688
36 ,, ...	..	..	8·055	..	..	..	..
25 ,, ...	..	..	..	..	..	5·905	..
24 ,, ...	5·720	..	..	5·973	5·944	..	..
20 ,, ...	..	..	6·725	..	..	..	6·097
12 ,, ...	4·580	..	..	..	4·744	..	..
10 ,, ...	..	6·637	5·137	..	..	6·692	4·840
7 ,, ...	..	5·870	..	..	..	5·807	..
Carronades.							
68-Pounder	8·050	..	..	..	..	..	..
42 ,, ...	6·840	..	..	..	..	..	..
36 ,, ...	..	..	..	..	6·791	..	..
32 ,, ...	6·250	..	..	..	..	..	..
30 ,, ...	..	..	..	..	6·413	..	..
24 ,, ...	5·680	..	..	..	5·933	..	..
18 ,, ...	5·160	..	..	..	5·417	..	..
12 ,, ...	4·520	..	..	..	4·748	..	..
6 ,, ...	3·600	..	..	..	..	..	..

Camp.—*Park,—Reconnoitering, —Tent.*

Camps are formed with a few trifling variations, after the same manner in all European Armies. It is a general rule, however, that the extent of the camp in front, the character and features of the ground being considered, shall not exceed the length of the line occupied by the troops drawn out in order of battle.

Armies are sometimes encamped in two lines, sometimes in three. The distance between these lines varies from two hundred to six hundred yards, according to the nature and face of the country.

The camp of a corps d'armée, division, or brigade, is composed of the encampments of its several battalions, squadrons, and batteries. It is therefore absolutely necessary that the space which each of these will occupy should be ascertained before the camp of the corps, division, or brigade can be traced, or the situation which each particular arm is to occupy, can be determined.

In regulating the extent of the front, 21 inches are allowed for each file of infantry; 3 feet for each file of cavalry. When the ground will permit, the tents of the infantry are arranged in rows perpendicular to the front, each row containing the tents of a company. The tents of the cavalry are disposed in the same order, each perpendicular row containing the tents and horses of a troop.

The grenadier and light infantry companies are usually placed in single rows on the flanks; the battalion companies in double rows in the interval between them. A single row, or company, occupies in front 17 feet (the diameter of a circular tent of the new pattern,) a double row, or two companies, 36 feet.

In the cavalry, a single row or troop occupies in front 57 feet, namely—

Diameter of the tent	17	feet
From the tent to the picket rope....	16	„
For the horse	18	„
„ „ manure	6	„
Total breadth of one row....	57	feet

Each tent is calculated to cover 15 men.

If therefore, the breadth of a row in front, whether for infantry or cavalry, be multiplied by the number of rows, and the product be subtracted from the extent of front required for a battalion, or squadron, the remainder will be the space to be allowed for the streets, which if they are to be of equal breadths, must be divided by their proposed number to find the breadth of each; or, it may be otherwise easily divided into streets of unequal breadths.

The ground will not at all times admit of each troop, or company being arranged in a single row perpendicular to the front, therefore in such cases divide the number of tents occupied by the battalion, or squadron by the number the ground will admit of in one row, and the remainder will be the number of perpendicular rows required.

If the battalion, or squadron be encamped in single rows, the number of streets will be one less than the number of rows, or if the battalion be encamped with its flank companies in single, and its battalion companies in double rows, the number of streets will be equal to half the number of companies.

It is usual when the character and nature of the ground will admit of it, to allow for each parallel line of tents,—

	Infantry.	*Cavalry.*	
From the quarter-guard to the line of parade of the battalion	62 yds.	,, yds.	Open to the front.
,, the line of parade to the first tents.	16 ,,	24 ,,	Open to the front.
To the first line of pickets	,,	5 ,,	The infantry tents open to the streets: the cavalry tents to the horses' heads.
For every tent in depth	6 ,,	6 ,,	
,, ,, horse ..	3 ,,	3 ,,	
From the infrantry tents or cavalry horses to the front of the subalterns' tents...	15 ,,	12 ,,	Open to the rear.
To the front of the captains' tents.	15 ,,	15 ,,	The captains' and subalterns' tents should be placed in rear of their respective troops or companies. The former open to the front.
,, the field officers' tents	10 ,,	15 ,,	Open to the front, opposite the outside streets of the battalion or squadron.
,, the colonel's tent........	10 ,,	10 ,,	The colonel's tent opens opposite the centre street of the battalion or squadron.
,, the staff officers' tents	10 ,,	10 ,,	Open up the streets adjoining the centre.

	Infantry.	*Cavalry.*	
To the bâtman's tent	10 yds.	15 yds.	The bâtmens' tents open to their horses' heads.
„ the first picket for bât horses	2 „		
„ the second do.	10 „		
„ the second row of bâtmen ..	2 „		
„ the mess tent	10 „	10 „	The mess tent is usually placed in rear of the colonel's.
„ the centre of the kitchens ..	15 „	20 „	Generally 16 feet in diameter.
„ the front of the suttler's tent.	15 „	15 „	Placed directly in rear of the kitchens.
„ the rear guard	15 „	15 „	Opens to the rear.

The above distribution contains the depth for one tent of each perpendicular row only. Consequently, the number of tents in a row, minus one, must be added to ascertain the total depth required for a battalion or squadron.

Camphor.—*Composition.*

A vegetable substance, in its ordinary state white, semi-transparent, and concrete. In many respects it resembles the essential oils, being like them volatile, inflammable, soluble in alcohol, and sparingly soluble in water. It is identical in its composition with pure oil of turpentine, and from its peculiarly inflammable qualities—burning in water—it is an excellent ingredient in the composition of fireworks. It has a clear flame, and gives out an agreeable odour.

Carcasses.—*Composition.*

Weight, Dimensions, etc. of Carcasses.

CARCASSES.	Calibre. Inches.	Weight. Empty.	Weight. Composition.	Weight. Filled.	Burns. Mins.
13-Inch Land Service	12·84	195 000	17·875	212·875	11·00
„ Sea „	12·84	213·750	14·500	228·250	9·25
10-Inch Land Service	9·84	90·250	7·250	97·500	8·50
„ Sea „	9·84	97·000	6·375	103·375	6·75
8-Inch Land Service	7·90	48·000	2·875	50·875	5·50
5 „ „ „	5·64	15·375	1·219	16·594	4·00
4⅖ „ „ „	4·46	8·375	·437	8·812	2·25

The above are the weights, dimensions, etc. of round carcasses, the only species now in the service.

Implements required—

- Mixing Tables
- „ Rubbers
- Hair Sieves
- Iron Pots
- Water Tubs
- Copper Pans
- „ Cylinders
- Fuze Plugs
- „ Drifts
- „ Mallets
- „ Ladles
- Kitt Kettles
- „ „ Trivets
- „ Brushes
- Spatulas

Shells filled with Valenciennes composition, so called from its having been first used by the Austrians at the siege of that place, are an excellent substitute for carcasses.

Implements required—

- Mixing Tables
- „ Rubbers
- Hair Sieves
- Copper Pans
- „ Cylinders
- „ Moulds
- Spatulas

Materials required to Complete 10 of each of the undermentioned Carcasses.

MATERIALS.	Carcasses.				
	13-Inch.	10-Inch.	8-Inch.	5½-Inch.	4⅖-Inch.
Empty Carcasses........	10	10	10	10	10
Salpetre, Ground ....lbs.	93·750	37·500	14·500	6·250	5·750
" Pulverised.. "	4·875	2·937	·750	·500	·375
Sulphur, Ground .... "	37·500	15·000	5·812	2·500	2·250
" Sublimed .. "	1·500	·750	·187	·125	·062
Rosin .... "	28·750	11·250	4·062	1·875	1·625
Mealed-Powder ...... "	4·125	2·000	·937	·687	·562
Antimony .... "	9·375	3·750	1·500	·625	·500
Tallow .... "	9·375	3·750	1·500	·625	·500
Venice Turpentine.... "	9·375	3·750	1·500	·625	·500
Quick-Match .... "	·312	·250	·125	·093	·077
Kitt .... "	5·000	4·500	4·000	2·500	1·500
Hessian ....yds.	1·250	1·000	·875	·750	·625

Carriage.—*Axletree,*—*Wheel.*

Carriages are divided into five classes:—Field Carriages,—Siege Carriages,—Transporting Carriages,—Garrison Carriages,—and Ship Carriages; each of which classes is further subdivided into numerous varieties.

Field Carriages.

Weight of Field Battery and Horse Artillery Carriages.

18-Pounder		4312	6293	7115
	Carriage	1981		
	Limber		822	
Waggon,	Limber	970	1546	3269
	Ammunition	576		
	Body	1003	1723	
	Ammunition	720		

Field Battery Carriages—*continued.*

8-Inch Howitzer	2324	4788	5610
Carriage	2464		
Limber		822	
Waggon, Limber	938	1478	3239
Ammunition	540		
Body	1041	1761	
Ammunition	720		
Spare Carriage, Limber	822	984	4241
Wheeler's Tools	162		
Carriage	1981	3257	
Stores, etc.	1276		
12-Pounder	2016	3453	4727
Carriage	1437		
Limber	986	1274	
Ammunition	288		
Waggon, Limber	928	1440	3208
Ammunition	512		
Body	1000	1768	
Ammunition	768		
9-Pounder	1512	2844	4159
Carriage	1332		
Limber	913	1315	
Ammunition	402		
Waggon, Limber	913	1315	3093
Ammunition	402		
Body	1004	1778	
Ammunition	774		

Field Battery Carriages—*continued:*

6-Pounder (Heavy)	1344	2602	3866
Carriage	1258		
Limber	920	1264	
Ammunition	344		
Waggon, Limber	902	1282	3087
Ammunition	380		
Body	1001	1805	
Ammunition	804		
24-Pounder Howitzer	1344	2744	4163
Carriage	1400		
Limber	927	1419	
Ammunition	492		
Waggon, Limber	927	1419	3159
Ammunition	492		
Body	1002	1740	
Ammunition	738		
Spare Carriage, Limber	963	1125	3669
Wheeler's Tools	162		
Carriage	1414	2544	
Stores, etc.	1130		
6-Pounder (Light)	672	1658	2927
Carriage	986		
Limber	901	1269	
Ammunition	368		
Waggon, Limber	901	1285	3086
Ammunition	384		
Body	1001	1801	
Ammunition	800		

Field Battery Carriages—*continued.*

3-Pounder (Heavy)	672	1620	2873
Carriage	948		
Limber	902	1253	
Ammunition	351		
Waggon, Limber	902	1217	2981
Ammunition	315		
Body	998	1764	
Ammunition	766		
12-Pounder Howitzer	741	1837	3132
Carriage	1096		
Limber	917	1295	
Ammunition	378		
Waggon, Limber	917	1295	2661
Ammunition	378		
Body	1002	1366	
Ammunition	364		
Spare Carriage, Limber	879	1041	2988
Wheeler's Tools	162		
Carriage	1076	1947	
Stores, etc.	871		
Forge Waggon, Limber	879	1563	3060
Smith's Tools	684		
Body	1016	1497	
Stores, etc.	481		
Store Waggon, Limber	879	918	3272
Collarmaker's Tools	39		
Body	1131	2354	
Stores, etc.	1223		

Mountain Carriages.

Weight of Mountain Service Carriages.

(By Mule Carriage.)

3-Pounder (Light)	252	468	976
Carriage	216		
Ammunition (Four Boxes)		508	
4⅖-Inch Howitzer	280	534	1308
Carriage	254		
Ammunition (Six Boxes)		774	

(By Draft.)

3-Pounder (Light)	252	508	1009
Carriage	256		
Ammunition (Six Boxes)		501	
4⅖-Inch Howitzer	280	574	1628
Carriage	294		
Ammunition (Ten Boxes)		1054	

Colonial Carriages.

Weight of Colonial Service Carriages.

3-Pounder (Medium)	336	787	1288
Carriage	451		
Limber	382	501	
Ammunition	119		
Car	434	670	
Ammunition	236		

COLONIAL SERVICE CARRIAGES—*continued.*

(*Old Pattern.*)

1-Pounder (Ammuzette)	280	681	1129
Carriage	401		
Limber	366	448	
Ammunition	82		
Car		434	599
Ammunition		165	

(*New Pattern.*)

1-Pounder (Ammuzette)	280	770	988
Carriage	250		
Ammunition (Four Boxes)	240		
Ammunition (Two Boxes)		218	

$4\frac{2}{5}$-Inch Howitzer	280	880	1396
Carriage	600		
Limber	380	516	
Ammunition	136		
Car		440	712
Ammunition		272	

Siege Carriages.

Weight of Siege Carriages.

24-Pounder	5320	8008	8830
Carriage	2688		
Limber		822	
18-Pounder	4312	6265	7087
Carriage	1953		
Limber		822	

Siege Carriages—*continued.*

12-Pounder	3640	5460	6282
Carriage	1820		
Limber	822		
10-Inch Howitzer	4440	7752	8574
Carriage	3308		
Limber	822		
8-Inch Howitzer	2324	4788	5610
Carriage	2464		
Limber	822		

Transporting Carriages.

Weight of Transporting Carriages.

Carts, Sling	1850
Store	994
Trench	293
Hand	275
Waggons, Platform	2375
Flanders	1737
Ball-Cartridge	1654
Baggage	2016
Devil-Carriages, Large	3221
Small	848
Drags, Large	1568
Small	598
Pontoon-Carriages (Old Construction)	1370
(New „)	1539

Garrison Carriages.

Weight and Dimensions of Garrison Gun Carriages.

DIMENSIONS, ETC.	CARRIAGES.						
	68-Pounder.	32-Pounder.	24-Pounder.	18-Pounder.	12-Pounder.	9-Pounder.	6-Pounder.
Weight of Gun.... Cwt.	60·000	56·000	50·000	42·000	34·000	28·500	23·000
Brackets.							
Top,—							
Length	2·250	5·479	5·396	5·209	5·042	5·000	4·917
Depth	·667	1·105	1·084	1·042	1·042	1·000	1·000
Bottom,—							
Length	5.667	6·271	6·176	5·959	5·750	5·709	5·646
Depth	1·646	1·105	1·084	1·042	1·042	1·000	1·000
Thickness ..	·645	·500	·459	·438	·375	·355	·313
Transoms.							
Breast,—							
Length	2·084	1·709	1·625	1·584	1·334	1·334	1·250
Depth	1·250	1.396	1·396	1·334	1·375	1·334	1·313
Thickness	·500	·500	·459	·438	·375	·355	·313
Centre,—							
Length	2·875	..	..	..	..	..	..
Depth	1·167	..	..	..	..	..	..
Thickness	·500	..	..	..	..	..	..
Horizontal,—							
Length	2·042	..	..	..	..	..	..
Depth	1·167	..	..	..	..	..	..
Thickness..	·500	..	..	..	..	..	..
Axletrees.							
Fore,—							
Length of Bed....	3·000	3·042	2·917	2·834	2·500	2·417	2·334
Depth ,, ...	·709	·917	·875	·875	·875	·875	·792
Breadth ,, ...	·646	·646	·563	·563	·563	·563	·479
Hind,—							
Length of Bed....	,,	3·042	2·917	2·834	2·500	2·417	2·334
Depth ,, ...	,,	·646	·563	·563	·563	·563	·479
Breadth ,, ...	,,	1·000	1·000	1·000	1·000	1·000	1·000
Length of Arm..	·834	·896	·813	·792	·792	·792	·750
Diameter ,, ..	·625	·625	·542	·542	·542	·542	·459

Weight, etc., Garrison Gun Carriages—*continued.*

DIMENSIONS, ETC.	CARRIAGES.						
	68-Pounder.	32-Pounder.	24-Pounder.	18-Pounder.	12-Pounder.	9-Pounder.	6-Pounder.
Trucks.							
Fore,—							
Diameter of	1·584	1·584	1·562	1·562	1·562	1·562	1·521
Hole..	·625	·625	·542	·542	·542	·542	·459
Width of Sole....	·552	·552	·417	·417	·417	·417	·355
Hind,—							
Diameter of	..	1·334	1·334	1·334	1·334	1·334	1·334
Hole..	..	·625	·542	·542	·542	·542	·459
Width of Sole....	..	·417	·375	·375	·375	·375	·292
Stool-Beds.							
Bed,—							
Length	..	2·917	2·834	2·709	2·709	2·709	2·667
Breadth, Greatest..	..	·834	·834	·792	·792	·792	·667
Least.....	..	·542	·542	·500	·500	·500	·417
Thickness.........	..	·355	·355	·355	·334	·334	·292
Stool,—							
Length	..	1·417	1·334	1·250	1·250	1·084	1·084
Breadth	..	·750	·667	·667	·667	·667	·667
Thickness	..	·396	·375	·375	·375	·375	·334
Quoins.							
Breadth, Greatest ..	..	·896	·792	·771	·792	·813	·771
Least......	..	·542	·521	·479	·479	·500	·459
Length	..	2·250	2·063	2·063	1·917	1·834	1·667
Thickness, Greatest..	..	·563	·563	·563	·521	·500	·479
Least	..	·229	·229	·229	·229	·209	·209
Directing Bars.							
Length	7·834	..	..	..	..	..	..
Breadth	·750	..	..	..	..	..	..
Thickness	·735	..	..	..	..	..	..
Guides.							
Length	3·792	..	..	..	..	..	..
Breadth	·334	..	..	..	..	..	..
Thickness	·313	..	..	..	..	..	..
Weight of Carriage, Cwt.		15·268	13·706	12·759	11·563	10·366	9·179

Veight and Dimensions of Garrison Howitzer Carriages.

DIMENSIONS, ETC.	CARRIAGES. 10-Inch.	8-Inch.	$5\frac{1}{2}$-Inch.	$4\frac{2}{5}$-Inch.
ght of Howitzer .... Cwt.	40·000	20,000		
Brackets.				
,—(Cast Iron)				
Length	2·229	2·042		
Depth	·750	·521		
Thickness	·479	·417		
om,—				
Length	6·000	5·000		
Depth	1·834	1·834		
Thickness	·542	·500		
Transoms.				
st,—				
Length	2·042	1·625		
Depth	1·334	1·250		
Thickness	·542	·459		
izontal,—				
Length	2·000	1·625		
Depth	1·417	1·167		
Thickness	·500	·417		
Axletrees.				
Length of Bed	3·042	3·000		
Breadth ,,	·646	·646		
Thickness ,,	·792	·792		
Length of Arm	·896	·896		
Diameter ,,	·625	·625		
Trail-Bearing—(Cast Iron).				
Length	·959	·959		
Depth	·396	·396		
Thickness	·334	·334		
Trucks.				
Diameter of	1·584	1·584		
Hole	·625	·625		
Width of Sole	·552	·552		
ght of Carriage Complete ...... Cwt.	16·000	13·000		

Weight and Dimensions of Garrison Block Trail Carronade Carriages.

DIMENSIONS, ETC.	CARRIAGES.						
	68-Pounder.	42-Pounder.	32-Pounder.	24-Pounder.	18-Pounder.	12-Pounder.	6-Pounder.
Weight of Carronade, Cwt.	36·000	22·000	17·000	13·000	10·000	6·000	4·750
Trail.							
Block,—							
Length	7·000	5·834	5·542	5·125	5·000	4·500	
Width	2·125	1·500	1·459	1·334	1·250	1·084	
Thickness	1·125	1·000	·959	·917	·875	·834	
Bearing,—(Cast Iron)							
Length	1·834	1·459	1·417	1·417	1·375	1·292	
Width	·834	·834	·834	·834	·792	·750	
Thickness	·750	·750	·750	·750	·750	·750	
Axletrees.							
Fore,—							
Length of Bed	2·417	2·209	2·125	2·000	1·917	1·750	
Depth ,,	·875	·834	·834	·834	·750	·813	
Breadth ,,	·625	·625	·625	·542	·542	·459	
Hind,—							
Length	..	..	..	..	..	..	
Depth	..	..	..	..	..	..	
Breadth	..	..	..	..	..	..	
Length of Arm	·875	·875	·875	·792	·792	·750	
Diameter ,,	·625	·625	·625	·542	·542	·459	
Trucks.							
Fore,—							
Diameter of	1·584	1·584	1 584	1·562	1·562	1·521	
Hole	·625	·625	·625	·542	·542	·459	
Width of Sole	·552	·552	.552	·417	·417	·355	
Hind,—							
Diameter of	..	..	..	..	..	..	
Hole	..	..	..	..	..	..	
Width of Sole	..	..	..	..	..	..	
Weight of Carriage .. Cwt.	17·750	10·500	9·000	8·000	7·000	6·250	

Sea-Service Carriages.

Weight and Dimensions of Sea-Service Gun Carriages.

IMENSIONS, ETC.	CARRIAGES.						
	10-Inch Gun.	68-Pounder.	68-Pounder.	32-Pounder.	32-Pounder.	32-Pounder.	32-Pounder.
eight of Gun....Cwt	84·000	65·000	50·000	64·000	56·000	48·000	40·000
Brackets.							
op,—							
Length	2·334	5·375	2·271	5·459	5·459	4·667	4·250
Depth	·667	1·125	·625	1·084	1·084	1·084	1·042
ottom,—							
Length........	6·292	6·167	5·584	6·209	6·209	5·500	4·834
Depth	1·250	1·084	1·875	1·084	1·084	·917	1·042
Thickness..	·500	·500	·500	·500	·500	·459	·459
Transoms.							
reast,—							
Length	2·167	1·979	2·042	1·834	1·750	1·667	1·667
Depth	1·000	1·334	·667	1·334	1·417	1·209	1·375
Thickness	·522	·500	·500	·500	·500	·459	·459
ntre,—							
Length				..	..	..	..
Depth				..	..	..	..
Thickness				..	..	..	..
orizontal,—							
Length ...				..	..	..	..
Depth				..	..	..	..
Thickness ..				..	..	..	..
Axletrees.							
re,—							
Length of Bed....	3·500	2·875	2·750	2·709	2·625	2·625	2·625
Depth „	·250	·771	·250	·771	·771	·771	·771
Breadth „	·250	·542	·250	·542	·542	·542	·542
ind,—							
Length of Bed....	..	3·167	..	3·084	3·000	3·000	3·000
Depth „	..	·542	..	·542	·542	·542	·542
Breadth „	..	1·334	..	1·000	1·000	1·000	1·000
Length of Arm	·834	·875	·292	·875	·875	·875	·875
Diameter „	·250	·521	·250	·521	·521	·521	·521

Weight, etc., Sea-Service Gun Carriages—*continued.*

DIMENSIONS, ETC.	CARRIAGES.						
	10-Inch Gun.	68-Pounder.	68-Pounder.	68-Pounder.	32-Pounder.	32-Pounder.	32-Pounder.
Trucks.							
Fore,—							
Diameter of......	1·375	1·500	1·375	1·500	1·500	1·500	1·500
Hole..	·250	·532	·250	·532	·532	·532	·532
Width of Sole	·500	·500	·500	·500	·500	·500	·500
Hind,—							
Diameter of......	..	1·334	..	1·334	1·334	1·334	1·334
Hole..	..	·532	..	·532	·532	·532	·532
Width of Sole	..	·500	..	·500	·500	·500	·500
Stool-Beds.							
Bed,—							
Length	3·792	2·917	..	2·917	2·917	2·542	2·542
Breadth, Greatest..	·917	·875	..	·875	·834	·834	·834
Least ..	·625	·542	..	·542	·500	·500	·500
Thickness	·375	·355	..	·355	·355	·334	·334
Stool,—							
Length	..	1·417	..	1·417	1·375	1·292	1·292
Breadth	..	·584	..	·500	·584	·479	·584
Thickness	..	·396	..	·396	·396	·396	·375
Quoins.							
Breadth, Greatest....	·834	·834	..	·855	·834	·750	·750
Least	·521	·563	..	·521	·500	·417	·417
Length	2·000	2·167	..	2·167	2·167	2·042	2·042
Thickness, Greatest..	·542	·563	..	·521	·584	·542	·542
Least	·209	·229	..	·271	·229	·167	·167
Directing Bars.							
Length		7·834	7·834	..	..	..	..
Breadth		·750	·750	..	..	..	..
Thickness		·375	·375	..	..	..	..
Guides.							
Length		3·792	3·792	..	..	..	..
Breadth		·334	·334	..	..	..	..
Thickness		·313	·313	..	..	..	..
Weight of Carriage, Cwt.		9·000	13·750	9·000	9·000	6·940	6·679

Weight, etc., Sea-Service Gun Carriages—*continued.*

DIMENSIONS, ETC.	CARRIAGES.						
	32-Pounder.	32-Pounder.	24-Pounder.	24-Pounder.	24-Pounder.	18-Pounder.	18-Pounder.
Weight of Gun... Cwt.	32·000	25·000	50·000	47·500	40·000	42·000	37·500
Brackets.							
Top,—							
Length	..	..	5·375	5·146	4·250	5·084	..
Depth	..	..	1·042	1·042	1·042	·855	..
Bottom,—							
Length	4·646	4·334	6·084	5·875	4·834	5·792	4·646
Depth	1·500	1·459	1·042	1·042	1·042	·855	1·417
Thickness..	·396	·355	·459	·459	·459	·417	·334
Transoms.							
Breast,—							
Length	1·542	1·542	1·667	1·667	1·667	1·542	1·375
Depth	·959	·834	1·375	1·375	1·375	1·084	·855
Thickness	·479	·459	·459	·459	·459	·417	·334
Centre,—							
Length	..	..	..	..	..	..	..
Depth	..	..	..	..	..	..	..
Thickness	..	..	..	..	..	..	..
Horizontal,—							
Length	..	..	..	..	..	..	..
Depth	..	..	..	..	..	..	..
Thickness ..	..	..	..	..	..	..	..
Axletrees.							
Fore,—							
Length of Bed....	..	..	2·625	2·625	2·625	2·334	2·334
Depth „	..	..	·771	·771	·771	·709	·709
Breadth „	..	..	·542	·542	·542	·500	·500
Hind,—							
Length of Bed....	..	..	3·000	3·000	3·000	2·792	2·792
Depth „	..	..	·542	·542	·542	·500	·500
Breadth „	..	..	1·000	1·000	1·000	1·000	1·000
Length of Arm	..	..	·875	·875	·875	·792	·792
Diameter „	..	..	·521	·521	·521	·479	·479

Weight, etc., Sea Service Gun Carriages—*continued.*

DIMENSIONS, ETC.	CARRIAGES.						
	32-Pounder.	32-Pounder.	24-Pounder.	24-Pounder.	24-Pounder.	18-Pounder.	18-Pounder.
Trucks.							
Fore,—							
Diameter of	..	..	1·500	1·500	1·500	1·500	1·500
Hole	..	..	·532	·532	·532	·489	·489
Width of Sole	..	..	·500	·500	·459	·417	·417
Hind,—							
Diameter of	..	..	1·334	1·334	1·334	1·250	1·250
Hole	..	..	·532	·532	·532	·482	·489
Width of Sole	..	..	·500	·500	·459	·417	·417
Stool-Beds.							
Bed,—							
Length	..	..	2·917	2·709	2·542	2·729	2·500
Breadth, Greatest	..	..	·834	·834	·834	·813	·813
Least	..	..	·500	·500	·500	·479	·479
Thickness	..	..	·334	·334	·334	·334	·334
Stool,—							
Length	..	..	1·292	1·292	1·292	1·250	1·250
Breadth	..	..	·584	·584	·584	·417	·500
Thickness	..	..	·375	·375	·375	·375	·375
Quoins.							
Breadth, Greatest	..	..	·750	·750	·750	·667	·709
Least	..	..	·417	·417	·417	·417	·417
Length	..	..	2·042	2·042	2·042	2·042	2·000
Thickness, Greatest	..	..	·500	·500	·500	·417	·459
Least	..	..	·167	·167	·167	·167	·167
Directing Bars.							
Length	..	..	..	..	..	..	..
Breadth	..	..	..	..	..	..	..
Thickness	..	..	..	..	..	..	..
Slides.							
Length			..	..	..	..	..
Breadth			..	..	..	..	..
Thickness			..	..	..	..	..
Weight of Carriage, Cwt.			7·679	6·697	6·679	5·902	5·500

Weight, etc. Sea-Service Gun Carriages—*continued*.

MENSIONS, ETC.	CARRIAGES.						
	18-Pounder.	18-Pounder.	18-Pounder.	12-Pounder.	12-Pounder.	12-Pounder.	9-Pounder.
ight of Gun .. Cwt.	22·000	20·000	15·000	34·000	33·000	29·500	28·500
Brackets.							
p,—							
Length	..	..	..	4·959	4·750	4·334	..
Depth	..	..	..	·813	·792	·771	..
ttom,—							
Length........	4·834	4·250	4·000	5·584	5·375	4·917	5·250
Depth	1·459	1·250	1·209	·813	·792	·771	1·459
Thickness..	·334	·355	·334	·375	·375	·375	·334
Transoms.							
east,—							
Length	1·375	1·375	1·375	1·417	1·417	1·417	1·375
Depth	·875	·750	·625	1·042	1·042	·979	·855
Thickness......	·334	·355	·334	·375	·375	·375	·334
ntre,—							
Length	..	..	..	..	..	..	..
Depth	..	..	..	..	..	..	..
Thickness......	..	..	..	..	..	..	..
orizontal,—							
Length	..	..	..	..	..	..	..
Depth .. .	..	..	..	..	..	..	..
Thickness..	..	..	..	..	..	..	..
Axletrees.							
re,—							
Length of Bed ..	1·917	2·000	1·875	2·167	2·167	2·167	1·917
Depth „ ..	·667	·500	·542	·667	·667	·667	·667
Breadth „ ..	·438	·459	·396	·459	·459	·459	·438
ind,—							
Length of Bed ..	2·292	..	..	2·459	2·459	2·459	2·292
Depth „ ..	.438	..	..	·459	·459	·459	·438
Breadth „ ..	1·000	..	..	1·000	1·000	1·000	1·000
Length of Arm	·667	·709	·646	·709	·709	·709	·667
Diameter „	·417	·438	·375	·438	·438	·438	·417

Weight, etc., Sea-Service Gun Carriages—*continued.*

DIMENSIONS, ETC.	CARRIAGES.						
	18-Pounder.	18-Pounder.	18-Pounder.	12-Pounder.	12-Pounder.	12-Pounder.	9-Pounder.
Trucks.							
Fore,—							
Diameter of......	1·334	1·334	1·334	1·334	1·334	1·334	1·3
Hole..	·427	·448	·385	·448	·448	·448	·4
Width of Sole....	·334	·375	·334	·375	·375	·375	·3
Hind,—							
Diameter of......	1·167	..	..	1·167	1·167	1·167	1·1
Hole..	·427	..	..	·448	·448	·448	·4
Width of Sole....	·334	..	..	·375	·375	·375	·3
Stool-Beds.							
Bed,—							
Length	2·250	2·334	2·209	2·646	2·542	2·375	2·3
Breadth, Greatest..	·729	·709	·667	·750	·750	·750	·75
Least	·417	·417	·417	·438	·438	·438	·43
Thickness	·250	·271	·271	·292	·292	·292	·29
Stool,—							
Length	1·000	1·167	1·000	1·167	1·167	1·167	1·08
Breadth	·355	·334	·334	·417	·396	·334	·37
Thickness	·313	·334	·209	·334	·334	·334	·33
Quoins.							
Breadth, Greatest ..	·563	·542	·521	·709	·563	·542	·56
Least......	·334	·292	·292	·417	·375	·355	·33
Length	1·709	1·792	1·667	1·792	1·792	1·792	1·70
Thickness, Greatest..	·355	·334	·334	·459	·417	·355	·41
Least	·125	·105	·084	·125	·125	·125	·12
Directing Bars.							
Length	..	..	..	..	..	..	..
Breadth	..	..	..	..	..	..	..
Thickness	..	..	..	..	..	..	..
Guides.							
Length	..	..	..	..	..	..	..
Breadth	..	..	..	..	..	..	..
Thickness	..	..	..	..	..	..	..
Weight of Carriage, Cwt.	3·250			4·929	4·608	4·295	·93

Weight, etc., Sea-Service Gun Carriages—*continued.*

DIMENSIONS, ETC.	CARRIAGES.						
	9-Pounder.	9-Pounder.	6-Pounder.	6-Pounder.	6-Pounder.	6-Pounder.	6-Pounder.
Weight of Gun....Cwt.	26·000	25·000	22·000	21·000	20·000	18·000	17·000
Brackets.							
Top,—							
Length	..	..	..	..	..	..	..
Depth	..	..	..	..	..	..	..
Bottom,—							
Length	4·834	4·646	4·834	4·605	4·417	4·209	4·000
Depth	1·438	1·417	1·417	1·334	1·334	1·334	1·334
Thickness	·334	·334	·292	·292	·262	·292	·292
Transoms.							
Breast,—							
Length	1·375	1·375	1·250	1·250	1·250	1·250	1·250
Depth	·855	·855	·876	·792	·792	·792	·792
Thickness	·334	·334	·292	·292	·292	·292	·292
Centre,—							
Length	..	..	..	..	..	..	..
Depth	..	..	..	..	..	..	..
Thickness	..	..	..	..	..	..	..
Horizontal,—							
Length	..	..	..	..	..	..	..
Depth	..	..	..	..	..	..	..
Thickness..	..	..	..	..	..	..	..
Axletrees.							
Fore,—							
Length of Bed	1·917	1·917	1·750	1·750	1·750	1·750	1·750
Depth ,, ...	·667	·667	·605	·605	·605	·605	·605
Breadth ,, ...	·438	·438	·396	·396	·396	·396	·396
Hind,—							
Length of Bed....	2·292	2·292	2·167	2·167	2·167	2·167	2·167
Depth ,, ...	·438	·438	·396	·396	·396	·396	·396
Breadth ,, ...	1·000	1·000	1·000	1·000	1·000	1·000	1·000
Length of Arm	·667	·667	·605	·605	·605	·605	·605
Diameter ,,	·417	·417	·375	·375	·375	·375	·375

Weight, etc., Sea-Service Gun Carriages—*continued.*

DIMENSIONS, ETC.	CARRIAGES.						
	9-Pounder.	9-Pounder.	6-Pounder.	6-Pounder.	6-Pounder.	6-Pounder.	6-Pounder.
Trucks.							
Fore,—							
Diameter of	1·334	1·334	1·167	1·167	1·167	1·167	1·167
Hole ..	·427	·427	·386	·386	·386	·386	·386
Width of Sole	·334	·334	·292	·292	·292	·292	·292
Hind,—							
Diameter of	1·167	1·167	1·000	1·000	1·000	1·000	1·000
Hole..	·427	·427	·386	·386	·386	·386	·386
Width of Sole	·334	·334	·292	·292	·292	·292	·292
Stool-Beds.							
Bed,—							
Length	2·250	2·250	2·250	2·250	2·125	1·917	1·917
Breadth, Greatest..	·750	·750	·729	·729	·729	·729	·729
Least	·438	·438	·417	·417	·417	·417	·417
Thickness	·292	·292	·250	·250	·250	·250	·250
Stool,—							
Length	1·084	1·084	1·000	1·000	1·000	1·000	1·000
Breadth	·375	·375	·355	·355	·355	·355	·355
Thickness	·334	·334	·313	·315	·313	·313	·313
Quoins.							
Breadth, Greatest ...	·563	·563	·584	·584	·563	·563	·438
Least	·334	·334	·313	·313	·313	·313	·313
Length	1·709	1·709	1·417	1·417	1·417	1·417	1·334
Thickness, Greatest..	·355	·355	·396	·396	·396	·396	·334
Least	·125	·125	·125	·125	·125	·125	·125
Directing Bars.							
Length	..	..	..	..	..	..	..
Breadth	..	..	..	..	..	..	..
Thickness	..	..	..	..	..	..	..
Guides.							
Length	..	..	..	..	..	..	..
Breadth	..	..	..	..	..	..	..
Thickness	..	..	..	..	..	..	..
Weight of Carriage, Cwt.	3·813	3·250	3·419	3·250	3·000		

Carronade.—*Carriage,—Cartridge,—Charge.*

Weight, Dimensions, etc., of English and French Carronades in English Measures.

DIMENSIONS, ETC.	CARRONADES.							
	68-Pounder.	42-Pounder.	36-Pounder.	32-Pounder.	24-Pounder.	18-Pounder.	12-Pounder.	6-Pounder.
English.								
Diameter Base Ring..	1·850	1·597	..	1·456	1·307	1·196	1·050	·965
Muzzle....	1·031	·882	..	·796	·729	·657	·579	·454
Length, Feet.........	5·145	4·536	..	3·976	3·610	3·275	2·697	2·750
Calibres	7·767	7·660	..	7·633	7·635	7·616	7·159	9·166
Dispart	·409	·358	..	·330	·289	·269	·236	·256
Tangent............	·036	·034	..	·026	·025	·019		
Bore,—								
Calibre	·671	·570	..	·521	·474	·430	·377	·300
Length, Feet....	4·447	3·902	..	3·553	3·229	2·920	2·392	2·475
Calibres..	6·628	6·844	..	6·820	6·821	6·792	6·351	8·250
Chamber,—								
Depth	·639	·467	..	·423	·382	·354	·304	·275
Diameter ..	·566	·517	..	·469	·420	·372	·338	·267
Weight .... Cwt.	36	22	..	17	13	10	6	5
French.								
Diameter Base Ring..	..	..	1·675	..	1·480	1·352	1·176	..
Muzzle....	..	..	1·149	..	1·005	·912	·801	..
Length, Feet.........	..	..	4·445	..	3·807	2·507	2·943	..
Calibres.....	..	..	7·855	..	6·799	7·769	7·440	..
Dispart	..	..	·213	..	·243	·220	·138	..
Tangent............	..	..						
Bore,—								
Calibre	..	..	·566	..	·495	·452	·396	..
Length, Feet....	..	..	3·752	..	3·196	2·886	2·446	..
Calibres..	..	..	6·628	..	6·465	6·393	6·183	..
Chamber,—								
Depth.......	..	..	·649	..	·575	·554	·483	..
Diameter ..	..	..	·525	..	·459	·419	·336	..
Weigh .... Cwt.	..	..	23	..	15	11	8	..

CARTRIDGE.—***Charge,—Gun,—Howitzer,—Carronade.*** **Weight, Dimensions, etc., of Field, Siege, Garrison, and Sea-Service Cartridges.**

ORDNANCE.	Charge.	DIMENSIONS.			WEIGHT.			Packed in a Box.
		Length.	Breadth.		Box.		50 Empty Cartridges.	
			Greatest.	Least.	Empty.	Filled.		
FIELD.								
12-Pounder	4·000	1·375	1·209	1·209	27·38	78·03	3·906	12
9 „	3·000	1·092	1·083	1·083	20·50	59·50	3·563	12
6 Pounder	2·000	1·184	·959	·959	25·50	77·75	2·719	24
	1·500	·934	·959	·959	24·75	64·75	2·250	24
3-Pounder	1·000	·809	·750	·750	19·00	51·63	1·656	20
	·750		·750	·750	19·00	44·03		34
	·625		·750	·750				
1-Pounder	·375	·709	·525	·525				
24-Pounder Howitzer	2·500	1·017	1·667	1·050	28·75	82·63		20
12 „ „ ..	1·250	·900	1·418	·977	25·00	68·75		22
$4\frac{2}{5}$-Inch „ ..	·500	·634			24·50	63·00	1·063	72
SIEGE, ETC.								
68-Pounder	11·000	1·584	2·108	2·108			8·375	
32 „	10.667	1·817	1·659	1·659			7·938	
24 „	8·000	1·525	1·467	1·467	36·82	120·19	6·250	10
18 „	6·000	1·584	1·375	1·375			6·000	
12 „	4·000	1·375	1·209	1,209	27·38	78·03	3·906	12
9 „	3·000	1·092	1·083	1·083	20·50	59·50	3·563	12
6 „	2·000	1·184	·959	·959	25·50	77·75	2·719	24
10-Inch Howitzer ..	7·000	1·150	2·034	1·617	28·13	79·13		8
8 „ „	4·000	1·142	2·200	1·167	24·00	84·03		14
SEA SERVICE.								
10-Inch Gun	12·000	1·625	2·584	2·000	40·69	150·69	8·635	9
68-Pounder	12·000	1·645	2·500	1·334	40·69			9
	9·000	1·500	2·250	1·334	40·69			10
	8·000	1.459	2·000	1·334	40·69	154·69	7·813	14
	7·000	1·334	2·000	1·334	40·69			16

Weight, etc., Ordnance Cartridges—*continued.*

ORDNANCE.	Charge.	DIMENSIONS.			WEIGHT.			Packed in a Box.
		Length.	Breadth.		Box.		50 Empty Cartridges.	
			Greatest.	Least.	Empty.	Filled.		
SEA SERVICE—*con.*								
2-Pounder............	10·667	1·817	1·659	1·659	40·69	149·13	7·938	10
	8·000	1·396	1·659	1·659	40·69	154·25	6·313	14
	6·000	1·250	1·659	1·659	40·69	156·69	5·344	19
	5·000	1·167	1·659	1·659	40·69	152·69	4·937	22
	4·000	1·063	1·659	1·659	40·69	150·69	3·532	27
	3·000	1·042	1·659	1·659	40·69	153·69	3·250	37
-Pounder...........	8·000	1·525	1·467	1·467	40·69		6·250	14
	7·000	1·417	1·467	1·467	40·69			
	6·000	1·334	1·467	1·467	40·69	156·69	5·750	19
	5·000	1·250	1·467	1·467	40·69			
	4·000	1·167	1·467	1·467	40·69	150·69		27
8-Pounder...........	6·000	1·584	1·375	1·375	40·69		6·000	19
	4·500	1·334	1·375	1·375	40·69	150·69	5·000	24
	4·000	1·209	1·375	1·375	40·69			
	3·000	1·084	1·375	1·375	40·69	150·69	3·844	36
	2·000	·916	1·375	1·375	40·69	152·69	2·813	55
2-Pounder............	4·000	1·375	1·209	1·209	40·69	158·25	3·907	29
	3·000	1·167	1·209	1·209	40·69	157·32	3·375	38
	2·000	1·084	1·209	1·209	40·69	153·50	2·803	55
-Pounder............	3·000	1·092	1·083	1·083	40·69	161·25	3·263	39
	2·250	1·000	1·083	1·083	40·69	156·32	3·063	50
	1·500	·875	1·083	1·083	40·69	154·07	2·375	74
-Pounder............	2·000	1·184	·959	·959	40·69	159·38	2·687	58
	1·500	1·000	·959	·959	40·69	150·94	2.250	72
	1·000	·750	·959	·959	40·69	146·94	1·875	104
CARRONADES.								
-Pounder............	5·625	1·192	1·750	1·750	40·69	157·19	5·032	20
2 „	3·500	1·417	1·592	1·592	40·69	154·19	3·710	32
2 „	2·625	1·500	1·459	1·459	40·69	147·44	3·297	40
4 „	2·000	·917	1·325	1·325	40·69	157·94	2·875	55
8 „	1·500	·834	1·150	1·150	40·69	150·69	5·531	72
2 „	1·000	·734	1·100	1·100	40·69	144·69	1·985	102
6 „	·750	·625	·842	·842	40·69			

Materials required to Complete 100 Field, Siege, Garrison, and Sea-Service Cartridges.

ORDNANCE.	Charge.	Materials.			Weight of Gun.
		Serge.	Worsted.	Powder.	
Field.					
12-Pounder	4·000	69·00	·125	400·0	18·00
9 "	3·000	60·00	·125	300·0	13·50
6-Pounder	2·000	36·00	·094	200·0	12·00
	1·500	31·50	·094	150·0	6·00
3-Pounder	1·000	27·00	·070	100·0	6·00
	·750	24·00	·062	75·0	3·00
	·625	23·25	·062	62·5	2·50
1-Pounder	.375	21·00	·062	37·5	2·50
24-Pounder Howitzer	2·500	73·50	·125	250·0	
12 " "	1·250	45·00	·125	125·0	
4$\frac{2}{5}$-Inch "	·500	16·50	·062	50·0	
Siege and Garrison.					
68-Pounder	11·000	159·00	·250	1100·0	60·00
32 "	10·667	165·50	·250	1068·8	
24 "	8·000	150·00	·219	800·0	
18 "	6·000	90·00	·188	600·0	
12 "	4·000	69·00	·125	400·0	
9 "	3·000	54·00	·125	300·0	28.50
6 "	2·000	60·00	·094	200·0	23·00
10-Inch Howitzer	7·000	118·50	·188	700·0	
8 " "	4·000	79·50	·188	400·0	
Sea Service.					
10-Inch Gun	12·000	147·00	·250	1200·0	84·00
68-Pounder	12·000	166·50	·250	1200·0	65·00
	9·000	150·00	·250	900·0	
	8·000	144·00	·250	800·0	
	7·000	133·50	·250	700·0	
32-Pounder	10·667	165·50	·250	1068·8	64·00
	8·000	135·00	·219	800·0	

MATERIALS to complete Ordnance Cartridges—*continued.*

ORDNANCE.	Charge.	Materials.			Weight of Gun.
		Serge.	Worsted.	Powder.	
SEA SERVICE—*continued.*					
32-Pounder	6·000	126·00	·188	600·0	
	5·000	117·00	·188	500·0	
	4·000	66·00	·140	400·0	
	3·000	66·00	·140	300·0	
24-Pounder	8·000	150·00	·219	800·0	
	7·000	144·00	·219	700·0	
	6·000	139·50	·188	600·0	
	5·000	81·00	·157	500·0	
	4.000	72·00	·140	400·0	
18-Pounder	6·000	90·00	·188	600·0	
	4.500	60·00	·125	450·0	
	4·000	57·00	·125	400·0	
	3·000	54·00	·125	300·0	
	2·000	45.00	·094	200·0	
12-Pounder	4·000	69·00	·125	400·0	
	3·000	54·00	·125	300·0	
	2·000	36·00	·094	200·0	
9-Pounder	3·000	60·00	·125	300·0	
	2·250	45·00	·094	225·0	
	1·500	36.00	·079	150·0	
6-Pounder	2·000	36·00	·094	200·0	
	1·500	31·50	·094	150·0	
	1·000	27·00	·079	100·0	
CARRONADES.					
68-Pounder	5·625	90·00	·157	562·5	
42 „	3·500	72·00	·141	350·0	
32 „	2·625	66·00	·125	262·5	
24 „	2·000	54·00	·125	200·0	
18 „	1·500	42·00	·094	150·0	
12 „	1·000	36·00	·094	100·0	
6 „	·750	21·00	·062	75·0	

General Table of Musquet, Carbine, Rifle, and Pistol Cartridges.

DIMENSIONS, ETC.	Arms.					
		Carbine.			Pistol.	
	Musquet.	Rifle Bore.	Musquet Bore.	Rifle.	Rifle Bore.	Musquet Bore.
Charges.						
Proof .... drs.	23·334	15·000				
Service .... „	6·000	4·000	5·500	4·000	3·000	3·500
Exercise .... „	5·000	4·000	4·500	4·000	3·000	3·000
Formers.						
Length of Body	·438	·425	·438	·425	·425	·438
Handle	·055	·063	·055	·063	·063	·055
Diameter Greatest	·055	·050	·055	·050	·050	·055
Least	·054	·049	·054	·049	·049	·054
Depth of Hollow	·017	·015	·017	·015	·015	·017
Papers.						
Forming,—						
Length	·442	·429	·442	·429	·429	·442
Breadth, Greatest	·596	·500	·596	·500	·500	·596
Least ..	·313	·217	·313	·217	·217	·313
Cut from a Sheet	12	16	12	16	16	12
Packing,—						
Cut from a Sheet	4	6	4	6	6	4
Package.						
In a Bundle....	10	10	10	10	10	10
Box	1000	1300	1080	1300	1500	1350
Weight.						
Cartridges	93·813	85·625	97·250	85·625	94·500	111·500
Box, Empty	12·250	12·250	12·250	12·250	12·250	12·250
Filled	160·188	98·188	109·625	98·313	106·938	123·875

Note.—The shape of the forming paper is that of a right angled trapezoid; and, by the length given above is to be understood, the distance between its two parallel edges.

" The service charges given in this table, although established by authority, are too great, and might be advantageously reduced by about one-fourth. They have not been altered since 1775, while the strength of the powder has been increased in nearly a two-fold ratio since that period."

This note was written in 1828 and published in the first and second editions of this work. The charges established in 1838, for the new pattern arms—which are all of musquet-bore—are, for the musquet 4½, for the carbine 3½, and for the rifle 2½ drams. Pistols are no longer in the service, except for the navy, and the coast guard.

The implements required, are:—

Scissors, pairs	2	Bobbin Spikes	4
Knives, Long	1	Filling Boxes	2
Short	1	Sieve Bottoms	1
Formers	2	Measures	1
Choakers	2	Funnels	1

With these implements two men, or two experienced boys, can form, and pack, into bundles, about 1000 musquet cartridges a-day,—the day being reckoned at 10 working hours.

Musquet, etc. ammunition was usually packed, during the late war, in half or quarter barrels, and transported in two-wheeled carts. It is now packed in deal boxes and carried in limber-waggons, so constructed as to carry each twenty boxes, namely, eight on the limber, and twelve on the body of the waggon.

Both these changes are great improvements, but the construction of the limber is faulty. The exigencies of the service may occasionally require that the limber should be disengaged from the body of the waggon, to be sent forward, at a rapid rate, to any point where a supply of ammunition may, on the instant, be required. It should therefore be so constructed as to convey, at the same time, two men to serve out the cartridges.

MATERIALS required to complete 1000 Musquet, Carbine, Rifle, and Pistol Cartridges.

MATERIALS.	ARMS.					
		Carbine.			Pistol.	
	Musquet.	Rifle Bore.	Musquet Bore.	Rifle.	Rifle Bore.	Musquet Bore.
SERVICE.						
Gunpowder F. G. .... lbs.	23·500	15·688	20·547	15·688	11·782	13·745
Lead .... „	68·938	50·000	68·938	50·000	50·000	68·938
Dutch Thread ...... „	4·938	3 875	4·938	3·875	3·875	4·938
Packing Twine ...... „	2·500	1·813	2·500	1·813	1·500	1·563
Paper, Fine White.... qrs.	3·834	2·875	3·834	2·875	2·875	3·834
„ Whited Brown „	1·917	1·917	1·917	1·917	1 917	1·917
EXERCISE.						
Gunpowder F. G. .... lbs.	19·536	15·688	17·594	..	11·782	11·782
Dutch Thread ...... „	2·188	2·188	2·188	..	2·188	2·188
Packing Twine ...... „	1·188	1·188	1·188	..	1·188	1·188
Paper, Blue or Purple, qrs.	3·834	2·875	3·834	..	3·188	3·438

The above are the exact quantities of each article required. A trifling allowance must be made for waste of paper, in forming and packing the cartridges, as also for Dutch thread or twine.

CHAMBER.—*Gun,—Howitzer,—Mortar,—Carronade.*

It has been found by experiment that chambers have no sensible effect on the velocity of shot, unless in the largest description of ordnance, neither is the form of them very material, though mathematical speculations may shew a preference of one form over another. A small cylinder is as good as any. The chief points to be attended to, in practice, are, that the capacity of the chamber shall be just sufficient to contain the charge and no more,—that the projectile shall lay close to the powder,—and that its centre shall coincide with the axis of the charge.

In the year 1787-9, experiments were carried on at Woolwich with an 8-inch mortar, and four shifting chambers, to ascertain which form would give the longest range. The forms of these chambers were,—

1. Conical, with hemispherical bottom.
2. The same form reversed.
3. Cylindrical, with hemispherical bottom.
4. Spherical.

They were all of the same capacity, namely, 63·7 cubic inches, and contained a charge of 2 lbs. of powder.

The ranges were a medium of six rounds, and from them it appears, that the spherical chamber, with a full charge, has the advantage;—but that with smaller charges, its ranges are shorter than those of the other forms. The conical chamber (No. 1) was found to give the longest range under all circumstances. The result of subsequent experiments, proves, that a parabolic chamber and lodgment is preferable to any other.

1. *To find the Content of a Cylindrical Chamber.*

To the length of the cylinder, add ⅓ of its diameter, and multiply that sum by the area of its circular, section for the content. That is,—

$$(L + \tfrac{1}{3} D) \times D^2 n = C.—$$

L, length of the cylinder;—D, its diameter;—n, ·7854;—and C, the content of the chamber.

The length or depth of a cylindrical chamber, not including the depth of the hemispherical end, being 7, and the diameter, 5·4 inches, required its content?

Here, $(L + \frac{1}{3}D) \times D^2.n = 8{\cdot}8 \times 22{\cdot}902 = 201{\cdot}538$ Cubic inches.

2. *To find the Content of a Gomer Chamber.*

To three times the product of the two diameters, add the square of their difference, and multiply that sum by ¼ of the length or depth of the chamber for the content. That is,—

$$(3.\,D\,d + \delta^2) \times \tfrac{1}{4}L = C.$$

D, d, diameters of the chamber;—and δ, their difference.

The diameters of a gomer chamber being respectively 8 and 4, and the depth, 10 inches, required its content?

Here, $(3.\,D\,d + \delta^2) \times \frac{1}{4}L = 112 \times 2{\cdot}5 = 280$ Cubic inches.

3. *To find the quantity of Powder a given Chamber will Contain.*

Divide the content of the chamber, computed by either of the foregoing rules, in cubic inches, by 30, and the quotient will be the quantity of powder in pounds.

The content of a gomer chamber being 285 cubic inches, required the quantity of powder which it will contain?

Here, $285 \div 30 = 9{\cdot}5$ lbs.

CHARCOAL.—*Composition,—Gunpowder.*

A black, insoluble, inodorous, insipid, brittle, vegetable substance; an excellent conductor of electricity, but a bad conductor of heat: unchangeable by the combined action of air and moisture at common temperatures, and easily combustible in oxygen gas. When pure, it is perfectly insoluble at all known temperatures.

Charge.—*Cartridge,—Proof,—Bomb-Vessel.*

General Table of Charges for Field, Siege, Garrison, and Sea-Service Ordnance.

ORDNANCE.		SERVICE.			EXERCISE.			
	Proof.	High.	Medium.	Low.	Exercise.	Short Practice.	Blank Exercise.	Weight of Gun.
FIELD.								
12-Pounder	5·000	4·000	..	..	..	..	..	18·00
9 "	3·500	3·000	..	..	..	..	..	13·50
6-Pounder	3·000	2·000	..	..	..	..	..	12·00
	2·000	1·500	..	..	..	..	..	6·00
3-Pounder	1·500	1·000	..	..	..	..	..	6·00
	1·000	·750	..	..	..	..	..	3·00
	1·000	·625	..	..	..	..	..	2·50
1-Pounder	1·000	·375	..	..	..	..	..	2·50
24-Por. Howitzer..	3·000	2·500	..	..	..	..	..	13·50
12 " " ..	1·500	1·250	..	..	..	..	..	6·50
$4\frac{2}{5}$-Inch " ..	·500	·500	..	..	..	..	..	2·50
SIEGE, ETC.								
68-Pounder	18·000	11·000	..	..	..	..	..	60·00
32 "	21·000	10·667	..	..	..	..	..	56·00
24 "	18·000	8·000	..	..	..	..	..	50·00
18 "	15·000	6·000	..	..	..	..	..	42·00
12 "	12·000	4·000	..	..	..	..	..	34·00
9 "	9·000	3·000	..	..	..	..	..	28·50
6 "	6·000	2·000	..	..	..	..	..	23·00
10-Inch Howitzer..	12·000	7·000	..	..	..	..	..	40·00
8 " " ..	8·000	4·000	..	..	..	..	..	20·00
SEA SERVICE.								
10-Inch Gun......	18·000	..	12·000	..	12·000	..	6 000	84·00
68-Pounder	20·000	..	12·000	..	..	..	..	65·00
	18·000	..	9 000	..	5·000	..	4·500	60·00
	14·000	..	7·000	..	4·000	..	3·500	50·00
32-Pounder	21·500	10·667	8·000	6·000	6·000	..	2:750	64·00
	21·500	10·667	8·000	6·000	6·000	..	2:750	56·00

Charges for Field, etc., Ordnance—*continued.*

ORDNANCE.	Proof.	SERVICE.			EXERCISE.			Weight of Gun.
		High.	Medium.	Low.	Exercise.	Short Practice.	Blank Exercise	
SEA SERVICE—*con.*								
32-Pounder	21·500	..	8·000	6·000	6·000	2·750	2·750	48
	12·000	..	6·000	5·000	5·000	2·000	2·000	40
	10·000	..	5·000	4·000	4·000	2·000	2·000	32
	9·000	..	4·000	3·000	3·000	2·000	2·000	25
24-Pounder	18·000	8·000	6·000	4·000	4·000	2·000	2·000	50
	18·000	8·000	6·000	4·000	4·000	2·000	2·000	47
	18·000	8·000	6·000	4·000	4·000	2·000	2·000	40
18-Pounder	15·000	6·000	4·500	3·000	3·000	1·500	1·500	42
	15·000	6·000	4·500	3·000	3·000	1·500	1·500	37
	7 000	..	3·000	2·000				22
	7·000	..	3·000	2·000				20
	5·000	..	2·000					15
12-Pounder	12·000	4·000	3·000	2·000	2·000	1·000	1·000	34
	12·000	4·000	3·000	2·000	2·000	1·000	1·000	33
	12·000	4·000	3·000	2·000	2·000	1·000	1·000	29
9-Pounder	9·000	3·000	2·250	1·500	1·500	·750	·750	
6 "	6·000	2·000	1·500	1·000	1·000	·509	·500	
CARRONADES.								
68-Pounder	13·000	5·625	..	..	..	..	..	36·0
42 "	9·000	3·500	..	..	..	..	..	22·
32 "	8·000	2·625	..	..	..	..	..	17·
24 "	6·000	2·000	..	..	..	..	..	13·
18 "	4·000	1·500	..	..	..	..	..	10·
12 "	3·000	1·000	..	..	..	..	..	6·
6 "	1·500	·625	..	..	..	..	..	4·
MORTARS.								
13-Inch	9·000	9·000	..	..	..	..	..	16·
10 "	4·000	4·000	..	..	..	..	..	36·
8 "	2·000	2·000	..	..	..	..	..	8·
5½ "	·438	·438	..	..	..	..	..	1·
4⅖ "	·313	·313	..	..	..	..	..	1·

Observations on the Charges of Ordnance.

I have inserted, in the preceding table, the charges of naval ordnance, though I do not profess to understand the principle on which those charges are determined. They were established in 1832—3, previous to which period all *iron guns* were similarly charged,—by one-third of the weight of the shot. By this change a step has been made in advance, but only a step, and I think I may venture to assert that, at no very distant date, this vitally important subject must again become matter of serious investigation with those on whom the duty and responsibility of maintaining our maritime superiority devolves. In the meantime, I here republish the observations appended to this article in the two former editions of this work.

The service charges of guns vary from one-third to one-fourth, or even less, and, for carronades, from one-eighth to one-sixteenth of the shot's weight. In most ordinary cases of service this proportion is too high, especially for naval ordnance. If the charges of ship guns were reduced to one-fourth, or even to one-fifth of the shot's weight, experience proves that considerable advantage would result; not only would the guns be kept cooler and quieter, and the ammunition be economized, but the injury to the enemy's vessels would, at the same time, be much greater. With the present charges the guns are overheated, and their tackle and furniture strained; and this, only to render the ball less efficacious than it would prove if it were impelled by a smaller charge.

In breaching walls, which cannot be penetrated by a single shot from any given piece of ordnance whatever, the velocity of the ball, how much soever augmented, still produces a proportionate effect by augmenting the depth to which it penetrates. But the sides of the strongest ships.—the greater part of their timbers being of limited thickness—are insufficient to resist the generality of shot fired from a reasonable distance, even with a less charge than is here proposed (1). And it is matter of experiment that a ball, which can just pass through a piece of timber, and loses almost all its motion thereby, has a much better chance of rending and fracturing it, than if it passed through with a much greater velocity.

Robins, from whose works the above remarks are principally extracted, further observes that *the charge of a piece of ordnance is not to be determined by the greatest velocity that may be produced, but that it should be such a quantity of powder as will produce the least velocity necessary to the object in view;* and, if the windage be moderate, as it is at present, no field gun should be loaded with a greater charge of powder than one-sixth, or, at the utmost, one-fifth of the weight of its shot; nor should the charge of any battering gun exceed one-third of the weight of its shot.

Dr. Hutton, in his paper published in the Philosophical Transactions for 1778, observes that different charges of powder with the same weight of ball produce different velocities in the ball which are in the sub-duplicate ratio of the weights of the powder; and, when the weight of the powder is the same, and that of the ball varied, the velocity produced is in the reciprocal sub-duplicate ratio of the weight of the ball; which is agreeable both to theory and practice. But this is on the supposition that the gun is of an indefinite length: whereas, on account of the limited length of

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(1.) On the 2nd January, 1838, an experiment was made in the practice ground, with a 24-pounder iron gun, of 37 cwt. 2 qrs. 11 lbs., mounted on a sea service carriage with breeching, etc., to ascertain the effect of its fire on a bulkhead, representing the sides of a ship of the line, at a range of 1250 yards. The charge of powder was 5 lbs. the elevation of the gun, 2¾ degrees, the recoil was by no means violent, and the fifth shot fired—the only one which struck the object—passed through one side of it, and penetrated into the other a depth equal to its simi-diameter.

guns, there is some variation from this law, in practice as well as in theory, in consequence of which it appears that the velocity of the ball increases with the charge only to a certain point which is peculiar to each particular gun, where the velocity is greatest, and that, by farther increasing the charge, the velocity further diminishes till the bore is quite full of powder.

By an easy fluxionary process, it is found that, calling the length of the gun's bore B, the length of the charge producing the greatest velocity ought to be

$$\frac{B}{2{\cdot}718281828},$$

or, about three-eighths of the length of the bore;—but, for several reasons in practice, the length of the charge producing the greatest velocity falls short of that above mentioned, and the more so in proportion as the gun is longer. Dr. Hutton found from many experiments that the length of the charge, in terms of the bore, producing the greatest velocity in guns of various lengths of from 15 to 40 calibres was as follows:—

Length of	bore..	15	Length of	charge..	$\frac{3}{10}$
"	"	20	"	"	$\frac{3}{12}$
"	"	30	"	"	$\frac{3}{16}$
"	"	40	"	"	$\frac{3}{20}$

Chevaux-de-Frize.—*Fortification.*

Weight and Dimensions of Chevaux-de-Frize.

(Old Pattern,—Wood.)

Length of the Spears........			6	Feet	0	Inches	25
"	"	Barrel........	9	"	5	"	30
Square	"	"........	0	"	4	"	

Weight, with 20 Spears, complete....	55 lb.

Chevaux-de-Frize—*continued.*

(New Pattern,—Iron.)

							lb.
Length of the Spears	5	Feet	9	Inches	46
" " Barrel	6	"	0	"	19
Diameter " "	0	"	4	"	
Weight, with 12 Spears, complete					65 lb.

Composition.—*Blue-Lights,—Carcases,—Fuses.*

When two or more proportions are given for any of these compositions, the first is that recognized by authority.

On the Properties of the Ingredients used in Laboratory Compositions.

Gunpowder, both coarse and mealed, is a principal ingredient in most compositions. Its property is to give additional activity to the fire.—Mealed-powder, however, does not produce this effect in an equal degree with that which is coarse-grained.

The property of nitre is to slacken the fire; of sulphur and charcoal to sustain it.

Rosin, pitch, tar, oil, and tallow feed the fire, increase its intensity, and prolong its duration.

Alcohol, turpentine, and other spirits are employed solely to moisten the composition in mixing.—Antimony and camphor to produce a clear, and orpiment a pale blue flame.

BAVINS:—

Sulphur	90 lbs.
Powder	12 "
Rosin	120 "
Tallow	6 "
Swedish Pitch	60 "

Pulverize the Powder, dissolve the sulphur, rosin, pitch, and tallow in an iron pot, transfer the liquid to a copper, add the powder, and stir the composition till the incorporation is complete.

Note.—This composition is also used for dipping Curtains, Covers for Fire-Barrels, and Reeds.

BLUE-LIGHTS:—

Sulphur	1 lb.	12 oz.
Nitre	7 ,,	0 ,,
Red Orpiment	,,	8 ,,

Nitre	2 lbs.	4 oz.
Sulphur	,,	8 ,,
Antimony	,,	4 ,,
Orpiment	,,	1½ ,,

Pulverize the ingredients, rub them between the hands for about ten minutes, and pass them four times through a fine hair sieve.

CARCASES:—

Nitre	6 lbs.	4 oz.
Sulphur	2 ,,	0 ,,
Antimony	0 ,,	10 ,,
Rosin	1 ,,	14 ,,
Tallow	0 ,,	10 ,,
Turpentine	0 ,,	10 ,,

Nitre	6 lbs.
Corned-Powder	30 ,,
Swedish Pitch	12 ,,
Tallow	3 ,,

Nitre	50 parts.
Sulphur	25 ,,
Antimony	5 ,,
Rosin	8 ,,
Pitch	5 ,,

Nitre	5 lbs.	0 oz.
Sulphur	2 ,,	0 ,,
Antimony	0 ,,	8 ,,
Rosin	1 ,,	0 ,,
Tallow	0 ,,	8 ,,

Pulverize the dry ingredients, rub the nitre and sulphur, or nitre and powder, between the hands for ten minutes, and pass them through a hair sieve. Rub the antimony and rosin between the hands in like manner, and sift them over the nitre and sulphur, or nitre and powder, and pass the whole four times through the sieve. Melt the pitch or tallow in an iron pot, transfer the liquid to a copper, add the dry ingredients by degrees, and stir the composition till the manipulation is complete.

CHINESE LIGHTS:—

Nitre	50 parts.
Sulphur	16 ,,
Antimony	5 ,,
Orpiment	8 ,,

Pulverize the ingredients, rub the nitre and antimony between the hands for five or six minutes; rub the sulphur and orpiment between the hands in like manner; incoporate these two compounds, by rubbing them between the hands for ten minutes, and pass the composition four times through a fine sieve.

FIRE-BALLS:—

Nitre	4 lbs.	6 oz.
Sulphur	3 ,,	0 ,,
Powder	8 ,,	0 ,,
Alum	1 ,,	8 ,,
Starch	0 ,,	8 ,,
Rosin	5 ,,	8 ,,
Linseed Oil	½ pint.	
Oil of Spike	1 ,,	

Pulverize the dry ingredients, pass the nitre and sulphur through a hair sieve, sift the alum, starch, and rosin over them, and pass the whole three times through the sieve; moisten with the oil, and work the composition between the hands till the manipulation is complete.

FIRE-BARRELS:—

Nitre	6 lbs.
Corned-Powder	30 ,,
Tallow	3 ,,
Swedish Pitch	12 ,,

Pulverize the nitre; spread the powder on a table, sift the nitre over it, and rub the two between the hands for about ten minutes, melt the pitch and tallow, add the nitre and powder by degrees, and stir the liquid till the incorporation is complete.

FIRE-HOOPS:—

Nitre	3 lbs.	0 oz.
Sulphur	0 ,,	8 ,,
Powder	1 ,,	0 ,,
Linseed Oil	½ pint.	

Pulverize the dry ingredients and pass them four times through a hair sieve; moisten with the oil, add four ounces of roll sulphur, moderately bruised, and work the composition between the hands till the manipulation is complete.

Note.—This composition is also used for Fire-Arrows and Fire-Lances.

FUZES:—

Nitre	3 lbs.	4 oz.
Sulphur	1 ,,	0 ,,
Powder	2 ,,	12 ,,

Nitre	40 parts.
Sulphur	16 ,,
Powder	60 ,,

Pulverize the ingredients, rub them between the hands for ten minutes, and pass the mass four times through a fine hair sieve.

The following blind-fire composition is sometimes used in driving fuzes.

Powder	16 parts.
Wood Ashes	9½ ,,

Pulverize the powder, re-bake the ashes, sift them over the powder, rub the mixture between the hands for ten minutes, and pass it four times through the hair sieve.

KITT:—

Rosin	9 lbs.
Pitch	6 ,,
Tallow	4 ,,
Bees' Wax	6 ,,

Bruize the rosin, and dissolve the several ingredients in an iron pot. When used, the composition should be re-heated, but not boiled.

LIGHT-BALLS:—

Nitre	6 lbs.	5 oz.
Sulphur	2 ,,	8 ,,
Rosin	1 ,,	14 ,,
Linseed Oil	0 ,,	7½ ,,

Nitre	40 parts.
Sulphur	15 ,,
Antimony	3 ,,
Pitch	3 ,,

Pulverize the dry ingredients, rub them between the hands for about ten minutes, and pass them four times through a hair sieve. Boil the oil or pitch, add the dry ingredients by degrees, and stir the composition till the incorporation is complete.

PORTFIRES:—

Nitre	6 lbs.
Sulphur	2 ,,
Powder	1 ,,

Nitre	60 parts.
Sulphur	40 ,,
Powder	20 ,,

Pulverize the ingredients, rub them between the hands for about ten minutes, and pass the composition four times through a fine hair sieve.

Note—Sheets of soft brown paper dipped in a solution of nitre and rain water,—two ounces to a gallon,—dried and rolled into sticks seven-tenths of an inch in diameter, were used at the Siege of Gibraltar as a substitute for portfires.

QUICK-MATCH:—

Cotton Wick	1 lb.	12 oz.
Nitre	1 ,,	8 ,,
Powder	10 ,,	0 ,,
Alcohol	2 quarts.	
Rain Water	1½ ,,	

Pulverize the dry ingredients, put the nitre into a clean copper pan, unwind the cotton upon it, add the water, and boil for an hour. Add the alcohol, simmer the liquid and cotton over a slow fire, for a quarter of an hour, add one-half of the powder, and leave the cotton to soak for twenty-four hours.—Wind the cotton on a reel, sift the remainder of the powder over it, and leave it to dry for about ten days.

ROCKETS:—

Nitre	4 lbs.	4 oz.
Sulphur	0 ,,	12 ,,
Charcoal	2 ,,	0 ,,

Nitre	4 lbs.	0 oz.
Sulphur	1 ,,	0 ,,
Charcoal	1 ,,	8 ,,

Pulverize the ingredients, rub the nitre and charcoal between the hands for ten or twelve minutes, add the sulphur; pass the composition four times through a coarse hair sieve, and rub again between the hands till the manipulation is complete.

STARS:—

Nitre	8 lbs.	0 oz.
Sulphur	2 ,,	0 ,,
Powder	0 ,,	8 ,,
Antimony	2 ,,	0 ,,
Isinglass	0 ,,	3½ ,,
Alcohol	1 pint.	
Vinegar	2 ,,	

Pulverize the dry ingredients, dissolve the isinglass in the vinegar over a clear fire, rub the nitre, sulphur, powder, and antimony between the hands for about ten or twelve minutes, and pass them four times through a hair sieve. Pour the dissolved isinglass and alcohol into an earthen pan, add the dry ingredients, and work the composition into a stiff paste.

SMOKE-BALLS:—

Nitre	1 ℔.	0 oz.
Corned-Powder	5 „	0 „
Sea Coal	1 „	8 „
Swedish Pitch	2 „	0 „
Tallow	0 „	8 „

Pulverize the nitre and sea coal, bruize the powder, spread it on a table, and sift the nitre over it. Rub these ingredients between the hands for a few seconds, spread them on the table, and sift the sea coal over them; dissolve the pitch and tallow in an iron pot, add the dry ingredients, and stir the liquid till the incorporation is complete.

Note.—In filling the cases, add three proportions of the following dry composition:—

Sulphur	1 oz.
Sea Coal	1 „

One proportion when the case is one quarter filled, another when half filled, and the third when three quarters filled.

SUFFOCATING POTS:—

Nitre	5 parts.
Sulphur	6 „

Pulverize the ingredients, rub them between the hands for a few seconds, and pass them four times through a hair sieve.

V. COMPOSITION:—

Nitre	3 ℔s.	2 oz.
Sulphur	1 „	12 „
Antimony	1 „	2 „
Rosin	0 „	5 „

Pulverize the ingredients, melt them in an iron pot, and cast the composition into moulds.

Note.—The moulds vary in diameter with the fuzeholes of the shells in which the composition is to be used, and are in general about six inches in length.

CONVOYS.—*Horses,—Marching,—Reconnoitering.*

The rate at which a convoy can travel must depend on the mode of transport, the state of the roads, and the season of the year—whether by land or by water. If by land, whether by carriages, by bât-horses, mules, or asses. If by carriages, whether they are drawn by horses, mules, or oxen. Transport by water is at all times to be preferred to that by land, provided the period for the commencement of the intended operations is not thereby delayed beyond the time originally proposed.

A principal object to be attained in the marching of a convoy, is, the preservation of the cattle. If a convoy should consist, therefore, of many hundred waggons, it should be divided into divisions not exceeding 500 each. If of thousands, it would be advisable to divide it into grand divisions, and these into sub-divisions of 500 waggons each. In the formation of these several divisions, the different modes of transport should be kept as distinct as possible: neither should carriages of diverse kinds be admitted into the same division.

The departure of the several divisions, on the days of marching, must also be so timed as to ensure to each the longest possible period of rest; by which means, both the escort and the cattle will be saved much unnecessary fatigue till their immediate turn to move.

1. *To find the Time required to Drive Off a given Convoy.*

Multiply the number of waggons in the convoy by the rate of travelling one mile, and divide that product by the number (ex. gr. 100) in a mile, for the time required.

A division of 500 waggons can travel at the rate of two miles an hour. Required the time that will elapse between the driving off of the first and last of them?

Here, $\frac{(500 \times 30) \div 100}{60} = 2\frac{1}{2}$ Hours.

2. *To find the Time a Convoy will require to Travel a given Distance.*

Compute the time the convoy will occupy in driving off, by the preceding rule, and that time, plus the time a single waggon takes to travel the given distance, will be the time required.

A convoy of 1500 waggons can travel at the rate of three miles an hour. Required the time it will occupy in travelling a distance of 30 miles?

$$\text{Here, } \frac{(1500 \times 20) \div 100}{60} + 10 = 15 \text{ Hours.}$$

The above convoy is divided into three divisions of 500 waggons each, and the 1st division commences its march at 5 P.M. Required the hours at which the other divisions should, respectively, be ordered to assemble?

$$\text{Here, } \frac{(500 \times 20) \div 100}{60} = 1\tfrac{2}{3} \text{ Hours.}$$

$$\because 5 + 1\tfrac{2}{3} = 6\tfrac{2}{3}; \text{ and } 6\tfrac{2}{3} + 1\tfrac{2}{3} = 8\tfrac{1}{3}.$$

The 2nd division should therefore be ordered to assemble at precisely 20 minutes before 7, and the 3rd division at 20 minutes past 8 P.M., when they should instantly take up the line of march.

The escort should be divided into front, centre, and rear guards, besides the flankers, who should never be beyond musquet shot, or at most, four hundred yards from each other. The several divisions of the convoy should also be numbered, and should each day change the order of their marching. Whenever the progress of a division is arrested by the breaking down of a waggon, or by any other obstacle, all those in rear of the stoppage should immediately drive up into the first open space, and there remain until the cause of the delay is removed. This will keep the convoy together, and better under the protection of the escort.

CORDAGE.—*Exercise,—Materials,—etc.*

The weights, dimensions, etc. of the principal descriptions of cordage are given, from actual experiments, under the respective heads, Cables, Hawsers, and Ropes. The following approximative rules will be found sufficiently accurate for all practical purposes, in computing the weight, strength, etc. of any of the intermediate sizes.

1. *To find the Weight of a given Rope.*

Multiply the length of the rope, in fathoms, by the square of its circumference, in inches, and divide that product by 480 for the weight, in cwts.

Required the weight of 100 fathoms of $5\frac{3}{4}$ inch rope?

$$\text{Here, } \frac{100 \times 33{\cdot}0625}{480} = 6{\cdot}89 \text{ Tons.}$$

2. *To find the Weight a Rope will Support without Breaking.*

Divide the square of the circumference of the given rope, in inches, by 5 for the weight, in tons.

Required the strength of a 6-inch rope, or the weight which it will sustain without breaking?

$$\text{Here, } = \frac{6 \times 6}{5} = \frac{36}{5} = 7{\cdot}2 \text{ Tons.}$$

3. *To find the Size of a Rope to Sustain a given Weight.*

Multiply the given weight, in tons by 5, and take the square root of the product for the circumference of the rope, in inches.

Required the size of a rope to sustain 6 tons without breaking?

$$\text{Here,} = (6 \times 5)^{\frac{1}{2}} = (30)^{\frac{1}{2}} = 5{\cdot}48 \text{ Inches.}$$

ON THE STRENGTH OF CORDAGE.

By a series of experiments on tarred, and white, or untarred cordage, M. Duhamel has obtained the following results:—

White cordage in constant use is one-third more durable than the same cordage when tarred; it resists the ordinary injuries of the weather, one-fourth longer, and, when laid up in store, retains its strength for a much longer period.

The observations of seamen confirm these results of direct experiments, but it has been invariably found that tarred cordage is stronger than white, when the latter is exposed to be wet and dry alternately. Tarred cordage is therefore chiefly valuable for cables and ground tackle. Cordage superficially tarred is also found to be stronger than the same cordage when thoroughly tarred, and it resists better the alternations of the weather.

An experiment was tried in 1805, to determine the comparative advantages of teak and common tar, when applied to cordage. The ropes on which the experiment was made were prepared from the same yarns; they were each three inches in circumference, and they were laid up in the same store till 1807, when,—

The rope to which the common tar had been applied broke with a weight of 3,848, and the other with a weight of 5,980 lbs.—

The advantage is, therefore, as three to two, in favour of tar made from teak.

Dispart.—*Carriage,—Gun,—Tangent,—etc.*

Dispart, Tangent, etc. of Guns, Howitzers, and Carronades.

ORDNANCE.	LENGTH.			DIAMETER.		
	Gun.	Dispart.	Tangent.	Base Ring.	Re-inforce.	Muzzle.
FIELD.						
12-Pounder	6·550	·136	·112	1·319	·913	1·047
9 ,,	6·000	·088	·102	1·050	·835	·874
6-Pounder	7·000	·114	·119	·963	·754	·735
	5·000	·085	·085	·802	·625	·632
3-Pounder	6·000	·076	·102	·729	·567	·577
	4·000	·068	·068	·637	·500	·501
	3·000	·077	·050	·637	·492	·483
1-Pounder (Ammuzette)	5·000	·061	·085	·523	·402	·401
24-Pounder Howitzer	4·508	..	·079	1·000	·867	·911
12 ,, ,,	3·767	..	·066	·865	·850	·724
$4\frac{2}{5}$-Inch ,,	1·883	..	·033	·706	·706	·706
SIEGE, ETC.						
68-Pounder	8·834	·339	151	1·917	1·625	1·239
32 ,,	9·500	·241	·161	1·853	1·449	1·371
24-Pounder	9·500	·218	·162	1·745	1·375	1·308
	9·000	·228	·153	1·745	1·374	1·289
18-Pounder	9·000	·222	·154	1·473	1·296	1·029
	8·000	·205	·137	1·639	1·295	1·229
12-Pounder	9·000	·152	·154	1·478	1·167	1·174
	8·500	·214	·145	1·480	1·169	1·052
9-Pounder	8·500	·215	·146	1·388	1·106	·958
6 ,,	8·500	·178	·146	1·250	·988	·894
10-Inch Howitzer	5·000	..	·087	1·937	1·895	1·672
8 ,, ,,	4·000	..	·069	1·550	1 512	1·367
SEA SERVICE.						
10-Inch Gun	9·334	·250	·159	2·175	1·876	1·675
68-Pounder	9·000	·342	·153	1·950	1·667	1·276
	8·500	·265	·144	1·959	1·634	1·429

Dispart, Tangent, etc.—*continued.*

ORDNANCE.	LENGTH.			DIAMETER.		
	Gun.	Dispart.	Tangent.	Base Ring.	Re-inforce.	Muzzle.
SEA SERVICE—*continued.*						
68-Pounder	6·708	·200	·114	1·900	1·688	1·500
32-Pounder	9·583	·262	·163	1·854	1·549	1·330
	9·500	·241	·161	1·853	1·449	1·371
	8·000	·270	·136	1·869	1·500	1·329
	7·500	·178	·128	1·747	1·379	1·391
	6·500	·242	·110	1·650	1·334	1·166
	6·000	·196	·102	1·402	1·250	1·100
24-Pounder	9·500	·218	·162	1·745	1·375	1·308
	9·000	·228	·153	1·745	1·374	1·289
	7·500	·321	·128	1·704	1·442	1·062
18-Pounder	9·000	·222	·153	1·473	1·296	1·029
	8·000	·205	·136	1·639	1·295	1·229
	7·000	·206	·119	1·350	1·102	·938
	6·000	·171	·102	1·325	1·142	·983
	5·500	·150	·084	1·208	1·125	·908
12-Pounder	9·000	·152	·154	1·478	1·167	1·174
	8·500	·214	·145	1·480	1·169	1·052
	7·500	·194	·128	1·489	1·172	1·091
9-Pounder	8·500	·215	·145	1·388	1·106	·958
	7·500	·191	·128	1·402	1·109	1·020
	7·000	·175	·119	1·370	1·102	1·020
6-Pounder	8·000	·210	·137	1·251	·995	·831
	7·500	·189	·128	1·252	·993	·874
	7·000	·175	·119	1·250	·994	·900
	6·500	·165	·111	1·253	·989	·923
	6·000	·150	·094	1·255	·990	·955
CARRONADES.						
68-Pounder	5·145	·409	·036	1·849	..	1·031
42 „	4·536	·358	·034	1·597	..	·881
32 „	3·975	·329	·028	1·455	..	·797
24 „	3·610	·289	·025	1·307	..	·729
18 „	3·275	·269	·023	1·196	..	·658
12 „	2·697	·235	·018	1·050	..	·579
6 „	2·750	·256		·965	..	·453

DISTANCES.—*Levelling,—Sound,—etc.*

The heights and distances of inaccessible objects are usually determined by the mensuration and protraction of lines and angles.

If the angles enter into the problem, the lines are computed by trigonometry, and, in this case, a table of sines, tangents, etc., is absolutely necessary. The measure of the angles, however, may be disregarded,—in this case, the lines are computed by the geometrical property of similar triangles.

APPLICATION OF GEOMETRY TO THE MENSURATION OF HEIGHTS AND DISTANCES.

PROBLEM I.—To determine the Length of a Line accessible only at one Extremity.

Let it be required to determine the length of the line A F, (figure 2) the extremity F being inaccessible—

With a cord, or measuring tape, the longer the better, trace the line A B, in continuation of F A, —Trace also A D, equal to A B, in any convenient direction, and lay down B C, C D, each equal to A B or A D, which will complete the rhombus A B C D.—Mark the intersection of the imaginary line C F with A D, and measure A E, E D.—Then,—

$$\frac{AE \times CD}{DE} = AF. —$$

Required the distance between F, the interior crest of a ravelin, or bastion, and A, the proposed site of a ricochet or enfilading battery?

$$\text{Here, } \frac{AE \times CD}{DE} = \frac{80 \times 100}{20} = 400 \text{ Yards.}$$

PROBLEM II.—To determine the Length of an inaccessible Line.

Let it be required to determine the length of the line G H, (figure 3) both of its extremities being inaccessible.

Lay down the rhombus A B C D, as in the preceding problem, directing the sides A B, A D, to the extremities G and H, of the given line.—Mark the intersections of the imaginary lines B H, D G, with C D, C B, and measure E F.—Then,—

$$\frac{AG \times EF}{CE} = GH.—$$

Required the distance from G, the flank of an enemy's encampment, to H, a detached work, or other intrenchment?

$$\text{Here, } \frac{AG \times EF}{CE} = \frac{400 \times 30}{20} = 600 \text{ Yards.}$$

PROBLEM III.—To determine the Height of an Object accessible at its Base.

Let it be required to determine the height of the object E D, (figure 4) the base D being accessible.

Set up a staff of known length, A B, and measure B C, the extent of its shadow,—measure also D F, the shadow of the object.—Then,—

$$\frac{AC \times DF}{BC} = DE.—$$

Required the height of the revetment D E, or other obstacle which it is proposed to escalade?

$$\text{Here, } \frac{AC \times DF}{BC} = \frac{10 \times 30}{12} = 25 \text{ Feet.}$$

PROBLEM IV.—To determine the Height of an inaccessible Object.

Let it be required to determine the height of the object A B, (figure 5) its base being inaccessible.

Set up a staff at C, and another at D,—mark the intersection of the horizontal plane C B, and staff D E,—mark also the intersection of the visual line C A with D E, and measure C D, D E.—Then,—

$$\frac{CB \times DE}{CD} = AB.—$$

Required the command of the terreplein A, over the ground at D, the proposed site of a battery?

$$\text{Here, } \frac{CB \times DE}{CD} = \frac{1800 \times 3}{200} = 27 \text{ Feet.}$$

Application of Trigonometry to the Mensuration of Heights and Distances.

PROBLEM I.—To determine the Length of a Line (oblique to the horizon) accessible only at one Extremity.

Let it be required to determine the length of the oblique line A B, (figure 6) the extremity B being inaccessible, and the height A C known.

Observe the angle of depression D A B, equal to the angle of elevation A B C.—Then,—

$$AC \times \sec. CAB = AB.—$$

Required the range or distance of an elevated battery A, from a vessel B, at anchor,—the command A C of the battery being 160 feet, and the angle of depression D A B, 15 Degrees?

$$\text{Here, } AC \times \sec. CAB = 160 \times 3{\cdot}8638 = 618{\cdot}208 \text{ Feet.}$$

PROBLEM II.—To determine the Length of a Line (horizontal), accessible only at one Extremity.

Let it be required to determine the length of the line B C, (figure 7) the extremity C being inaccessible.

With a pocket sextant, compass, or other portable instrument, lay down the right angle A B C,—measure B A, and observe the angle A.—Then,—

$$AB \times \tan. A = BC.—$$

Required the distance between B and C, or the breadth B C of a river over which it is intended to throw a bridge, —the observed angle A being 67·25 Degrees?

$$\text{Here, } AB \times \tan. A = 400 \times 2{\cdot}3848 = 953{\cdot}92 \text{ yards.}$$

Note.—The height of an object, accessible at its base, may also be determined by this problem,—and, if the observer set his instrument to one of the annexed angles, and advance along the base till it accords with the angle of the object, the time otherwise required for the computation will be saved.

Angle A = 84,,17 . A B = $\frac{1}{10}$ B C nearly.
= 83,,39 . = $\frac{1}{9}$ B C ,,
= 82,,52 . = $\frac{1}{8}$ B C ,,
= 81,,52 . = $\frac{1}{7}$ B C ,,
= 80,,32 . = $\frac{1}{6}$ B C ,,
= 78,,41 . = $\frac{1}{5}$ B C ,,
= 75,,58 . = $\frac{1}{4}$ B C ,,
= 71,,34 . = $\frac{1}{3}$ B C ,,
= 63,,26 . = $\frac{1}{2}$ B C ,,
= 45,, . = B C exactly.

PROBLEM III.—To determine the Height of an inaccessible Object.

Let it be required to determine the height of an object C D, (figure 8) its base being inaccessible.

Observe the angles of elevation A and B, and measure the distance A B, between them.—Then,—

$$\frac{AB}{\text{Cot. } A - \text{Cot. } B} = CD.—$$

Required the height or command of a battery at C, over the plane A B,—the observed angles A and B, being respectively 15·25, and 32·75 degrees, and the distance between them A B, 800 feet?

$$\text{Here, } \frac{AB}{\text{Cot. } A - \text{Cot. } B} = \frac{800}{3{\cdot}668 - 1{\cdot}5547} = 378{\cdot}55 \text{ Feet.}$$

A TABLE OF NATURAL SINES, TANGENTS, and SECANTS, with their Complements for every Degree, and Quarter of a Degree of the Quadrant.

Deg.	Sine.	Cosec.	Tang.	Cotang.	Secant.	Cosine.	Deg.
·00	·00000	Infinite.	·00000	Infinite.	1·00000	1·00000	90·00
·25	·00436	229·18385	·00436	229·18166	1·00000	·99999	·75
·50	·00872	114·59301	·00872	114·58865	1·00003	·99996	·50
·75	·01309	76·39355	·01310	76·39000	1·00008	·99991	·25
1·00	·01745	57·29868	·01745	57·28996	1·00015	·99984	89·00
·25	·02181	45·84026	·02182	45·82935	1·00023	·99976	·75
·50	·02617	38·20155	·02618	38·18846	1·00034	·99965	·50
·75	·03053	32·74553	·03055	32·73026	1·00046	·99953	·25
2·00	·03490	28·65370	·03492	28·63625	1·00061	·99939	88·00
·25	·03926	25·47133	·03929	25·45170	1·00077	·99923	·75
·50	·04362	22·92558	·04366	22·90376	1·00095	·99904	·50
·75	·04797	20·84283	·04803	20·81882	1.00115	·99884	·25
3·00	·05233	19·10732	·05240	19·08113	1·00137	·99863	87·00
·25	·05669	17·63892	·05678	17·61055	1·00161	·99839	·75
·50	·06104	16·38040	·06116	16·34985	1·00186	·99813	·50
·75	·06540	15·28978	·06554	15·25705	1·00214	·99785	·25
4·00	·06975	14·33558	·06992	14·30066	1·00244	·99756	86·00
·25	·07410	13·49373	·07431	13·45662	1·00275	·99725	·75
·50	·07845	12·74549	·07870	12·70620	1·00309	·99691	·50
·75	·08280	12·07609	·08309	12·03462	1·00344	·99656	.25
5·00	·08715	11·47371	·08748	11·43005	1·00382	·99619	85·00
·25	·00150	10·92870	·09188	10·88292	1·00421	·99580	·75
·50	·09584	10·43343	·09629	10·38539	1·00462	·99539	·50
·75	·10018	9·98123	·10069	9·93100	1·00505	·99496	·25
6·00	·10452	9·56677	·10510	9·51436	1·00550	·99452	84·00
·25	·10886	9·18555	·10951	9·13093	1·00596	·99405	·75
·50	·11320	8·83367	·11393	8·77688	1·00647	·99357	·50
·75	·11753	8·50793	·11835	8·44895	1·00698	·99306	·25
7·00	·12187	8·20550	·12278	8·14434	1·00751	·99254	83·00
·25	·12620	7·92399	·12721	7·86064	1·00806	·99200	·75
·50	·13052	7·66129	·13165	7·59575	1·00863	·99144	·50
·75	·13485	7·41559	·13609	7·34786	1·00921	·99086	25
8·00	·13917	7·18529	·14054	7·11536	1·00982	·99026	82·00
·25	·14349	6·96900	·14500	6·89687	1·01045	·98965	·75
·50	·14781	6·76547	·14945	6·69115	1·01110	·98901	·50
·75	·15212	6·57361	·15391	6·49710	1·01177	·98836	·25
9·00	·15643	6·39245	·15838	6·31375	1:01246	·98768	81·00
·25	·16074	6·22112	·16286	6·14023	1·01317	·98699	·75
·50	·16504	6·05885	·16734	5·97576	1·01390	·98628	·50
·75	·16935	5·90494	·17183	5·81965	1·01465	·98555	·25
10·00	·17364	5·75877	·17632	5·67128	1·01542	·98480	80·00
·25	·17794	5·61976	·18083	5·53007	1·01621	·98404	·75
·50	·18223	5·48740	·18534	5·39551	1·01703	·98325	·50

Sines, Tangents, etc.—*continued.*

Deg.	Sine.	Cosec.	Tang.	Cotang.	Secant.	Cosine.	Deg.
10·75	·18652	5·36124	·18985	5·26715	1·01786	·98245	80·25
11·00	·19081	5·24084	·19438	5·14455	1·01871	·98162	79·00
·25	·19509	5·12583	·19891	5·02734	1·01959	·98078	·75
·50	·19936	5·01585	·20345	4·91515	1·02048	·97992	·50
·75	·20364	4·91058	·20800	4·80768	1·02140	·97904	·25
12·00	·20791	4·80973	·21256	4·70463	1·02234	·97814	78·00
·25	·21217	4·71303	·21712	4·60572	1·02330	·97723	·75
·50	·21644	4·62022	·22169	4·51070	1·02428	·97629	·50
·75	·22069	4·53110	·22627	4·41936	1·02528	·97534	·25
13·00	·22495	4·44541	·23086	4·33147	1·02630	·97437	77·00
·25	·22920	4·36399	·23546	4·24684	1·02734	·97338	·75
·50	·23344	4·28365	·24007	4·16530	1·02841	·97237	·50
·75	·23768	4·20723	·24469	4·08666	1·02950	·97134	·25
14·00	·24192	4·13356	·24932	4·01078	1·03061	·97029	76·00
·25	·24615	4·06251	·25396	3·93751	1·03174	·96923	·75
·50	·25038	3·99393	·25861	3·86671	1·03290	·96814	·50
·75	·25460	3·92770	·26327	3·79826	1·03407	·96704	·25
15·00	·25882	3·86370	·26795	3·73205	1·03527	·96592	75·00
·25	·26303	3·80183	·27263	3·66795	1·03649	·96478	·75
·50	·26723	3·74197	·27732	3·60588	1·03774	·96363	·50
·75	·27144	3·68405	·28203	3·54573	1·03901	·96245	·25
16·00	·27563	3·62795	·28674	3·48741	1·04030	·96126	74·00
·25	·27983	3·57361	·29147	3·43084	1·04161	·96005	·75
·50	·28401	3·52093	·29621	3·37594	1·04294	·95882	·50
·75	·28819	3·46985	·30096	3·32263	1·04430	·95757	·25
17·00	·29237	3·42030	·30573	3·27085	1·04569	·95630	73·00
.25	·29654	3·37220	·31050	3·22052	1·04709	·95502	·75
·50	·30070	3·32551	·31529	3·17159	1·04853	·95371	·50
·75	·30486	3·28014	·32010	3·12400	1·04998	·95239	·25
18·00	·30901	3·23606	·32492	3·07768	1·05146	·95105	72·00
·25	·31316	3·19321	·32975	3·03259	1·05296	·94970	·75
·50	·31730	3·15154	·33459	2·98868	1·05449	·94832	·50
·75	·32144	3·11100	·33945	2·94590	1·05604	·94693	·25
19·00	·32556	3·07155	·34432	2·90421	1·05762	·94551	71·00
·25	·32970	3·03314	·34921	2·86356	1·05922	·94409	·75
·50	·33380	2·99574	·35411	2·82391	1·06084	·94264	·50
·75	·33971	2·95931	·35903	2·78523	1·06250	·94117	·25
20·00	·34202	2·92380	·36397	2·74747	1·06417	·93969	70·00
·25	·34611	2·88919	·36892	2·06588	1·06588	·93819	·75
·50	·35020	2·85545	·37388	2·67462	1·06761	·93667	·50
·75	·35429	2·82253	·37886	2·63945	1·06936	·93513	·25
21·00	·35836	2·79042	·38386	2·60509	1·07114	·93358	69·00
·25	·36243	2·75909	·38887	2·57149	1·07295	·93200	·75
·50	·36650	2·72850	·39391	2·53864	1·07478	·93041	·50
·75	·37055	2·69863	·39896	2·50652	1·07664	·92881	·25
22·00	·37460	2·66946	·40402	2·47508	1·07853	·92718	68·00

Sines, Tangents, etc.—*continued.*

Deg.	Sine.	Cosec.	Tang.	Cotang.	Secant.	Cosine.	Deg:
22·25	·37864	2·64097	·40911	2·44432	1·08045	·92554	68·75
·50	·38268	2·61312	·41421	2·41421	1·08239	·92388	·50
·75	·38671	2·58591	·41933	2·38473	1·08436	·92220	·25
23·00	·39073	2·55930	·42447	2·35585	1·08636	·92050	67·00
·25	·39474	2·53328	·42963	2·32756	1·08838	·91879	·75
·50	·39875	2·50784	·43481	2·29984	1·09044	·91706	·50
·75	·40264	2·48295	·44001	2·27267	1·09252	·91531	·25
24·00	·40679	2·45859	·44522	2·24683	1·09463	·91354	66·00
·25	·41071	2·43475	·45046	2·21991	1·09677	·91176	·75
·50	·41469	2·41142	·45572	2·19430	1·09894	·90996	·50
·75	·41866	2·38857	·46100	2·16916	1·10114	·90814	·25
25·00	·42261	2·36620	·46630	2·14450	1·10337	·90630	65·00
·25	·42656	2·34128	·47163	2·12030	1·10563	·90445	·75
·50	·43051	2·32282	·47697	2·09654	1·10792	·90258	·50
·75	·43444	2·30178	·48234	2·07321	1·11025	·90069	·25
26·00	·43837	2·28117	·48773	2·05030	1·11260	·89879	64·00
·25	·44228	2·26096	·49314	2·02780	1·11498	·89687	·75
·50	·44619	2·24115	·49858	2·00569	1·11740	·89493	·50
·75	·45009	2·22173	·50404	1·98396	1·11984	·89297	·25
27·00	·45399	2·20269	·50952	1·96261	1·12232	·89100	63·00
·25	·45787	2·18400	·51503	1·94162	1·12483	·88901	·75
·50	·46174	2·16568	·52056	1·92098	1·12738	·88701	·50
·75	·46561	2·14770	·52612	1·90068	1·12996	·88498	·25
28·00	·46947	2·13005	·53171	1·88072	1·13257	·88294	62·00
·25	·47332	2·11273	·53732	1·86110	1·13521	·88089	·75
·50	·47715	2·09573	·54295	1·84177	1·13789	·87881	·50
·75	·48098	2·07905	·54861	1·82276	1·14060	·87672	·25
29·00	·48481	2·06266	·55431	1·80404	1·14335	·87462	61·00
·25	·48862	2·04657	·56002	1·78562	1·14613	·87250	·75
·50	·49242	2·03077	·56577	1·76749	1·14895	·87035	·50
·75	·49621	2·01525	·57154	1·74963	1·15181	·86819	·25
30·00	·50000	2·00000	·57735	1·73205	1·15470	·86602	60·00
·25	·50377	1·98501	·58318	1·71473	1·15762	·86383	·75
·50	·50753	1·97029	·58904	1·69766	1·16059	·86162	·50
·75	·51129	1·95582	·59493	1·68084	1·16359	·85940	·25
31·00	·51503	1·94160	·60086	1·66428	1·16663	·85716	59·00
·25	·51877	1·92762	·60681	1·64795	1·16971	·85491	·75
·50	·52249	1·91388	·61280	1·63185	1·17282	·85264	·50
·75	·52621	1·90036	·61881	1·61598	1·17598	·85035	·25
32·00	·52992	1·88708	·62487	1·60033	1·17917	·84804	58·00
·25	·53361	1·87401	·63095	1·58490	1·18241	·84572	·75
·50	·53730	1·86116	·63707	1·56968	1·18569	·84339	·50
·75	·54097	1·84851	·64322	1·55467	1·18900	·84104	·25
33·00	·54464	1·83607	·64940	1·53986	1·19236	·83867	57·00
·25	·54829	1·82384	·65562	1·52525	1·19576	·83628	·75
·50	·55193	1·81160	·66188	1·51083	1·19920	·8338	·50

Sines, Tangents, etc.—*continued.*

Deg.	Sine.	Cosec.	Tang.	Cotang.	Secant.	Cosine.	Deg.
33·75	·55557	1·79995	·66817	1·49660	1·20269	·83147	57·25
34·00	·55919	1·78829	·67450	1·48256	1·20621	·82903	56·00
·25	·56280	1·77681	·68087	1·46869	1·20979	·82659	·75
·50	·56640	1·76551	·68728	1·45501	1·21340	·82412	·50
·75	·56999	1·75439	·69372	1·44149	1·21706	·82164	·25
35·00	·57357	1·74344	·70020	1·42814	1·22077	·81915	55·00
·25	·57714	1·73266	·70673	1·41496	1·22452	·81664	·75
·50	·58070	1·72205	·71329	1·40194	1·22832	·81411	·50
·75	·58425	1·71159	·71989	1·38908	1·23217	·81157	·25
36·00	·58778	1·70130	·72654	1·37638	1·23606	·80901	54·00
·25	·59131	1·69116	73323	1·36382	1·24001	·80644	·75
·50	·59482	1·68117	·73996	1·35142	1·24400	·80385	·50
·75	·59832	1·67133	·74673	1·33916	1·24804	·80125	·25
37·00	·60181	1·66164	·75355	1·32704	1·25213	·79863	53·00
·25	·60529	1·65209	·76041	1·31506	1·25627	·79600	·75
·50	·60876	1·64268	·76732	1·30322	1·26047	·79335	·50
·75	·61221	1·63340	·77428	1·29151	1·26471	·79069	·25
38·00	·61566	1·62427	·78128	1·27994	1·26901	·78801	52·00
·25	·61909	1·61526	·78833	1·26849	1·27337	·78531	·75
·50	·62251	1·60638	·79543	1·25717	1·27777	·78260	·50
·75	·62592	1·59764	·80258	1·24597	1·28224	·77988	·25
39·00	·62932	1·58901	·80978	1·23489	1·28676	·77714	51·00
·25	·63270	1·58051	·81703	1·22393	1·29133	·77439	·75
·50	·63607	1·57213	·82433	1·21309	1·29596	·77162	·50
·75	·63944	1·56387	·83169	1·20237	1·30065	·76884	·25
40·00	·64278	1·55572	·83910	1·19175	1·30540	·76604	50·00
·25	·64612	1·54769	·84656	1·18124	1·31021	·76323	·75
·50	·64944	1·53977	·85408	1·17085	1·31508	·76040	·50
·75	·65276	1·53195	·86165	1·16055	1·32001	·75756	·25
41·00	·65606	1·52425	·86928	1·15036	1·32501	·75471	49·00
·25	·65934	1·51665	·87697	1·14028	1·33007	·75184	·75
·50	·66262	1·50916	·88472	1·13029	1·33519	·74895	·50
·75	·66588	1·50176	·89253	1·12040	1·34038	·74605	·25
42·00	·66913	1·49447	·90040	1·11061	1·34563	·74314	48·00
·25	·67236	1·48728	·90833	1·10091	1·35095	·74021	·75
·50	·67559	1·48018	·91633	1·09130	1·35634	·73727	·50
·75	·67880	1·47318	·92439	1·08179	1.36180	·73432	·25
43·00	·68199	1·46628	·93251	1·07236	1·36732	·73135	47·00
·25	·68518	1·45946	·94070	1·06303	1·37292	·72837	·75
·50	·68835	1·45274	·94896	1·05378	1·37859	·72537	·50
·75	·69151	1·44610	·95729	1·04462	1·38434	·72236	·25
44·00	·69465	1·43955	·96568	1·03553	1·39016	·71934	46·00
·25	·69779	1·43309	·97415	1·02652	1·39606	·71630	·75
·50	·70091	1·42671	·98269	1·01760	1·40203	·71325	·50
·75	·70401	1·42042	·99131	1·00876	1·40808	·71018	·25
45·00	·70710	1·41421	1·00000	1·00000	1·41421	·70710	45·00

DRAG-ROPES.—*Exercise,—Harness.*

Weight and Dimensions of Drag-Ropes.

(Eight Men.)

Length 23 Feet 6 Inches. Weight 32 ℔s.

(Six Men.)

Length 18 Feet 6 Inches. Weight 21 ℔s.

ELEVATION.—*Gunnery,—Ricochet.*

If the axis of a gun, and an object, however situated in regard to each other, and to their respective horizons, co-incide, or meet in the same plane, the direction of the gun, with reference to the position of the object, will evidently be *point-blank* or *direct;* and the range of the gun will be, cæteris paribus, directly as the magnitude of the angle included between its axis, and that *original direct or point-blank line*, unless the inclination of that line to the horizon be much greater than usually occurs in practice.

Hence it is manifest that *point-blank is the basis of elevation, in gunnery*, or that the elevation of a gun, with reference to an object, is, in ascending planes, equal to the difference of the angles of elevation of the gun and object above the horizon, and, in descending planes, to the difference of the angles of depression, of the object and gun below the horizon.

EMBARKATION.—*Artillery,—Tonnage,—Transport.*

Artillery is embarked either for removal from one situation to another, or with a view to active operations against an enemy. In the latter case, the officer appointed to command the artillery of the expedition should be furnished with an account of the transport provided, together with an accurate inventory of the various stores, placed under his charge. In this inventory, the tonnage of each separate article or package should be inserted, both by weight and measurement.

Field Artillery should be embarked by entire batteries,—each piece of ordnance being accompanied by every article appertaining to its particular service, together with its horses and ammunition, and a due proportion of the general stores provided for the intended operation or campaign.

If a battering train is to be embarked not only should every article appertaining to each piece of ordnance accompany it, but likewise every requisite for the construction of the battery on which it is eventually to be mounted. Siege artillery should always be embarked by divisions,—each division consisting of a relative proportion of the several natures of ordnance composing the train. This rule is without exception,—if it be not rigidly adhered to, the loss of a single transport may occasion the failure of an otherwise well-combined operation.

The several batteries and divisions should invariably be embarked under the personal superintendance of the officers appointed to command them, assisted by their respective commissaries or clerks of stores. The commanding officer having the general direction of the embarkation, will, of course, call the chief commissary to his assistance, and make his arrangements and regulate all the details of the service, in strict accordance with the plan and object of the projected enterprize.

EXERCISE—*Artillery,—Mechanics.*

The several Exercises are divided into three classes, as follows:—

Exercise of Field Artillery.

Exercise of Garrison or Siege Artillery.

Exercise of the various Machines employed in the manœuvres of Garrison or Siege Artillery.

Field Artillery.

Field Artillery is subdivided into Field Batteries, and Batteries of Horse Artillery.

Exercise of Field Batteries.

Each gun detachment consists of one non-commissioned officer and eight gunners.

Telling off of Detachments.

The detachments, formed two deep, right in front, are told off by their respective non-commissioned officers as follows:—

No. 2, the right-hand man of the rear rank,—3, his front rank man,—4, the second man from the right of the rear rank,—5, his front rank man;—and so on in succession from the right of the rear to the left of the front rank.

Note.—The non-commissioned officer is invariably No. 1, and he is responsible for the proper execution of their duties by the several numbers of his detachment.

Formation of Detachments in Order of March.

No. 1, in line with the heads of the wheel horses,—2 and 3, in line with the muzzle,—4 and 5, in line with the breech,—6 and 7, in line with the axle-tree of the limber,—8 and 9, in line with the splinter-bar.

Note.—The odd numbers are invariably on the off, and the even numbers on the near side of the gun and limber.

If the detachments should be ordered to the front, they take post in line ten yards in advance of the horses;—if to the rear, two yards behind the muzzles of their respective guns.

Disposition of Mounted Gun Detachments.

Nos. 1 and 2, on the right and left boxes of the gun limber,—3 and 4, on the corresponding boxes of the waggon limber,—5, 6, 7 and 8, on the body of the waggon,—5 and 6 on the front,—7 and 8 on the rear box,—9 (between 3 and 4) on the waggon limber.

Note.—In all manœuvres, as soon as the guns are limbered up, the detachments mount without waiting for orders.

Duties and Positions of the Numbers in Action.

No. 1, on the left of the handspike, points and commands,—2, outside the right wheel, in line with the muzzle, sponges,—3, in line with the muzzle outside the left wheel, loads,—4, in line with the breech, covering 2, serves the vent and primes,—5, covering 3, and in line with the breech, fires,—6, five paces in rear of, and covering the left wheel, serves 3 with ammunition,—7, in rear of the limber, supplies 6 with ammunition, and, when firing shells, fixes the fuzes,—8, ten yards in rear of 6, assists 7, and occasionally relieves 2,—9 attends the ammunition waggon.

Note.—In serving 24-pounder howitzers, No. 8 supplies No. 3 with shells.

Duties in Action, with Reduced Numbers.

Distribution of the Duties.

1	2	3	4	5	6	7	8	9
1.4.5	2.3.6							
1.4.5	2	3 6						
1	2	3.6	4.5					
1	2	3.6	4	5				
1	2	3	4	5	6			
1	2	3	4	5	6	7		
1	2	3	4	5	6	7	8	

Note.—The figures in the first line have reference to complete detachments, and the duties of the several numbers, as explained in the preceding article;

those in the vertical columns specify the additional duties which each number must perform with incomplete detachments; That is, with only four men to each gun; Nos. 3 and 4 must perform the duties of 6 and 5, in addition to their own.

Limbering Up, and Unlimbering.

May be done to the Front, Rear, Right, or Left, according to circumstances. In limbering up to the front, the trail is thrown round to the *left*, and the limber drives up to the *right* of the gun. In limbering up to the right or left the trail and limber both go to the *right* or *left*;—and, in limbering up to the rear, the limber drives up to the *right* of the trail, which is not thrown round, and reverses to the *left*. Unlimbering is precisely the reverse of the preceding.

MANŒUVRES OF FIELD BATTERIES.

Field Batteries consist of five guns, and one howitzer each, with their respective ammunition waggons, and other carriages. Each Battery is told off into Sub-Divisions, Divisions, and Half-Batteries.

Note.—A gun with its waggon constitutes a Sub-Division, —two Sub-Divisions a Division,—and three, a Half-Battery.

The Half-Batteries are told off as Right and Left; —the Divisions, as Right, Left, and Centre. The Sub-Divisions are numbered 1, 2, 3, 4, 5, and 6, from right to left, and told off as Right and Left Sub-Divisions of Divisions,—and Right, Left, and Centre Sub-Divisions of Half-Batteries.

Note.—The "*words*," both cautionary and executive, of the Commanding Officer, are printed in "CAPITALS" in the following manœuvres,—those of the Officers commanding Divisions and Sub-Divisions, in the ordinary text.—The *Italics*, distinguish the commands of caution from those of execution.

1. *A Battery—in Line,—to Form Column of Divisions to a Flank.*

	FORM COLUMN OF SUB-DIVISIONS IN REAR OF THE LEFT,		FORM COLUMN OF DIVISIONS IN FRON THE RIGHT—
6,	*Waggon Left.*	1,	*Waggon Left.*
5 4 3 2 1	*Left Reserve.*	2 3 4 5 6	*Left Shoulders.*
	March—		**March—**
5,	Right take Ground,—Right Wheel Up,—Halt Dress.	2 3 4 5 6	Right Shoulders,—Waggons Left,—Halt Dress.
4 3 2 1	Right Half Turn,—Right Wheel Up,—Halt Dress.		

2. *A Battery—in Line,—to advance or Retire a Flank in a Column of Sub-Divisions.*

	LEFT SUB-DIVISION TO THE FRONT—		LEFT SUB-DIVISION THE REAR.
6,	*Waggon Left.*	6,	*Left Reverse,—W Left.*
5 4 3 2 1	*Left take Ground.*	5 4 3 2 1	*Left take Ground.*
	March—		**March—**
5 4 3 2 1	Right Wheel, — Forward.	5 4 3 2 1	Left Wheel.

3. *A Battery—in Column of Sub-Divisions,—to form a Line to a Flank.*

LEFT OF THE FRONT FORM LINE—	RIGHT OF THE REAR FORM LINE—
1, *Waggon Rear.*	6, *Waggon Rear.*
2, *Left take Ground.*	5 4 3 2 1 } *Right take Ground.*
3 4 5 6 } *Right Shoulders,—Waggons Rear.*	
MARCH—	MARCH—
2, Right Wheel,—Halt Dress.	5, Right Wheel,—Right Reverse,—Halt Dress.
3 4 5 6 } Left Shoulders,—Halt Dress.	4 3 2 1 } Left Shoulders,—Right Reverse,—Halt Dress.

4. *A Battery—in Line,—to Form Columns of Divisions to a Flank.*

FORM COLUMN OF DIVISIONS IN REAR OF THE LEFT—	FORM COLUMN OF DIVISIONS IN FRONT OF THE RIGHT—
1 2 } *Left Reverse.*	2, *Forward.* 3, *Right Half Turn.*
MARCH.	MARCH—
2, Right take Ground,—Right take Ground,—Halt Dress.	2, Right take Ground,—Waggon Close Interval.
1, Right Half Turn,—Right Half Turn,—Right take Ground,—Halt Dress.	3, Right Half Turn,—Waggon Close Interval.
	2 3 } Right take Ground,—Halt Dress.

5. *A Battery—in Column of Sub-Divisions,—to Form Line on a Central Sub-Division.*

FORM LINE ON THE RIGHT CENTRE SUB-DIVISION—	FORM LINE ON THE LEFT CENTRE SUB-DIVISION—
3, *Waggon Rear.*	4, *Waggon Rear.*
1 2 } *Right take Ground.*	1 2 3 } *Right take Ground.*
4, *Left take Ground.*	5, *Left take Ground.*
5 6 } *Right Shoulders,—Waggons Rear.*	6, *Right Shoulders.*
MARCH—	**MARCH—**
2, Right Wheel,—Right Reverse, Halt Dress.	3, Right Wheel,—Right Reverse,—Halt Dress.
1, Left Shoulders,—Right Reverse,—Halt Dress.	1 2 } Left Shoulders,—Right Reverse—Halt Dress.
4, Right Wheel,—Halt, Dress.	5, Right Wheel,—Halt Dress.
5 6 } Left Shoulders,—Halt Dress.	6, Left Shoulders,—Halt Dress.

6. *A Battery—in Line,—to form Column of Half Batteries.*

FORM COLUMN OF HALF BATTERIES IN FRONT OF THE LEFT.	FORM COLUMN OF HALF BATTERIES IN REAR OF THE RIGHT.
1 2 3 } *Forward.*	4 5 6 } *Right Reverse.*
MARCH—	**MARCH.**
1 2 3 { Left take Ground,—Waggons Close Intervals,—Right take Ground,—Halt Dress.	4 5 6 } Left take Ground,—Left take Ground,—Halt Dress.

7. *A Battery—in Column of Divisions,—to Form Line to a Flank.*

RIGHT OF THE REAR FORM LINE—	LEFT OF THE FRONT FORM LINE—
2 1 *Right take Ground.*	2 3 *Left take Ground.*
MARCH—	MARCH—
2, Right take Ground,—Right Reverse,—Halt Dress.	2, Right take Ground,—Halt Dress.
1, Right Half Turn,—Right Half Turn,—Right Reverse,—Halt Dress.	3, Right Half Turn,—Right Half Turn,—Halt Dress.

8. *A Battery—in Column of Divisions, or Half-Batteries—to, Form Column of Half-Batteries, or Divisions.*

FORM COLUMN OF HALF-BATTERIES—	FORM COLUMN OF DIVISIONS—
1 2 4 *Right take Ground.*	1 2 *Left take Ground.*
3, *Left take Ground.*	3, *Right take Ground.*
	4, *Left take Ground,—Waggon close Interval.*
MARCH—	MARCH—
1 2 4 Right take Ground,—Right Reverse,—Halt Dress.	1 2 Right take Ground,—Halt Dress.
3, Right take Ground,—Halt Dress.	3, Right take Ground,—Right Reverse,—Halt Dress.
	4, Left Shoulders,—Halt Dress.

EXE.

9. *A Battery—in Column of Sub-Divisions, or Half Batteries,—to Form Column of Half-Batteries, or Sub-Divisions.*

FORM COLUMN OF HALF-BATTERIES—

1 2 4 5 *Right take Ground.*

3 6 *Waggons Rear.*

March—

1 4 Left Shoulders,—Left Shoulders, — Right Reverse,—Halt Dress

2 5 Right take Ground,—Right Reverse,—Halt Dress.

FORM COLUMN OF SUB-DIVISIONS—

3 6 *Waggons Right.*

1 4 *Right Shoulders.*

2 5 *Right Shoulders,—Waggons Forward.*

March—

1 4 Left Shoulders,—Waggons Right,—Halt Dress.

2 5 Left Shoulders,—Halt Dress.

10. *A Battery—in Line, or Column of Divisions,—to Form Column, or Line on the Centre Division.*

FORM COLUMN OF DIVISIONS ON THE CENTRE—

1, *Forward.*

3, *Right Reverse.*

March—

1, Left take Ground,—Waggon Close Interval,—Right take Ground,—Halt Dress.

3, Left take Ground,—Left take Ground,—Halt Dress.

FORM LINE ON THE CENTRE DIVISION—

1, *Right take Ground.*

2, *Left take Ground.*

March—

1, Right take Ground.—Right Reverse,—Halt Dress.

3, Right take Ground,—Halt Dress.

11. *A Battery—in Column of Divisions,—to Deploy into Line on the Centre or Rear Division on the Front Base.*

DEPLOY INTO LINE ON THE CENTRE DIVISION ON THE FRONT BASE—	DEPLOY INTO LINE ON THE REAR DIVISION ON THE FRONT BASE—
2, *Forward.*	1 2 } *Right take Ground.*
1, *Right take Ground.*	
3, *Left take Ground.*	
MARCH—	MARCH—
2, Halt Dress.	3, March,—Halt Dress.
1, Right take Ground,—Right Reverse,—Halt Dress.	2, Halt,—Left take Ground,—March,—Halt Dress.
3, Right take Ground,—Halt Dress.	1, Right take Ground,—Right Reverse,—Halt Dress.

12. *A Battery—in Line,—to Advance or Retire from a Flank in Column of Half Batteries.*

RIGHT HALF BATTERY TO THE FRONT—	LEFT HALF BATTERY TO THE REAR—
1 2 } *Forward.* 3	6 5 } *Inwards Wheel.* 4
4 5 } *Right take Ground.* 6	3 2 } *Left Wheel.* 1
MARCH—	MARCH—
4 5 } Left take Ground. 6	3 2 } Left Wheel. 1

13. *A Battery—in Line,—to Advance or Retire from a Flank in a Column of Divisions.*

LEFT DIVISION TO THE FRONT—

3, *Forward.*

1 2 } *Left take Ground.*

MARCH—

1 2 } Right take Ground.

LEFT DIVISION TO THE REAR—

3, *Sub-Divisions, inwards Wheel.*

1 2 } *Left Wheel.*

MARCH—

1 2 } Forward,—Left Wheel.

14. *A Battery—in Line,—to Form Column on a Central Sub-Division.*

FORM COLUMN ON THE RIGHT CENTRE—

1, *Right Shoulders.*

2, *Left take Ground,—Waggon forward.*

3, *Waggon Right.*

4 5 6 } *Right Reverse.*

MARCH—

2, Right take Ground,—Halt Dress.

4, Left take Ground,—Left Wheel Up,—Halt Dress.

1, Left Shoulders,—Waggons Right,—Halt Dress.

5 6 } Left Half Turn,—Left Wheel Up,—Halt Dress.

FORM COLUMN ON THE LEFT CENTRE—

1 2 } *Right Shoulders.*

3, *Left take Ground,—Waggon Forward.*

4, *Waggon Right.*

5 6 } *Right Reverse.*

MARCH—

3, Right take Ground,—Halt Dress.

5, Left take Ground,—Left Wheel Up,—Halt Dress.

1 2 } Left Shoulders,—Waggons Right,—Halt Dress.

6, Left Half Turn,—Left Wheel Up,—Halt Dress.

15. *A Battery—in Column of Sub-Divisions, or Divisions,—to Form Column of Divisions, or Sub-Divisions.*

FORM COLUMN OF DIVISIONS—	FORM COLUMN OF SUB-DIVISIONS—
1 3 5 } *Right take Ground.*	1 3 5 } *Right Shoulders,—Waggons Forward.*
2 4 6 } *Waggons Rear.*	4 5 6 } *Waggons Right.*
MARCH—	MARCH—
1 3 5 } Right Wheel,—Right Reverse,—Halt Dress	1 3 5 } Left Shoulders,—Halt Dress.

16. *A Battery—in Line,—to Advance or Retire from the Centre in Double Column of Route.*

ADVANCE FROM THE CENTRE IN DOUBLE COLUMN OF ROUTE—	RETIRE FROM THE CENTRE IN DOUBLE COLUMN OF ROUTE—
3 4 } *Forward.*	3 4 } *Left Reverse.*
1 2 } *Left take Ground.*	1 2 } *Left take Ground.*
5 6 } *Right take Ground.*	5 6 } *Right take Ground.*
MARCH—	MARCH—
1 2 } Right take Ground.	1 2 } Left take Ground.
5 6 } Left take Ground.	5 6 } Right take Ground.

17. *A Battery—in Line,—to Advance or Retire from a Flank in a Column of Route.*

ADVANCE FROM THE LEFT IN COLUMN OF ROUTE—	RETIRE FROM THE RIGHT IN COLUMN OF ROUTE—
6, *Forward.*	1, *Right Reverse.*
5 4 3 2 1 } *Left take Ground.*	2 3 4 5 6 } *Right take Ground.*
MARCH—	**MARCH—**
1 2 3 4 5 } Right take Ground.	2 3 4 5 6 } Right take Ground.

18. *A Battery—in Double Column of Route,—to Form Line from the Centre.*

ON THE RIGHT AND LEFT OF THE FRONT FORM LINE—	FORM LINE TO THE LEFT ON THE LEFT HALF BATTERY—
2, *Right Half Turn.* 5, *Left Half Turn.*	4 5 6 } *Waggons Left.*
1 6 } *Right and Left Shoulders.*	3 2 1 } *Left Wheel.*
MARCH—	**MARCH—**
2 5 } Left Half Turn,—Right Half Turn,—Halt Dress.	4 5 6 } Left take Ground,—Halt Dress.
1 6 } Left and Right Shoulders,—Halt Dress.	3 2 1 } Halt Dress.

19.—*A Battery—in Column of Half Batteries,—to Form Line to a Flank.*

LEFT OF THE FRONT FORM LINE—	RIGHT OF THE REAR FORM LINE—
4 5 } *Left take Ground.* 6	1 2 } *Right take Ground.* 3
March—	**March—**
4 5 } Right take Ground,— Halt Dress. 6	1 2 } Right take Ground,— Right Reverse,—Halt Dress. 3

Exercise of Horse Artillery.

Each gun detachment consists of two non-commissioned officers, both mounted, and six gunners with light, eight with medium, and ten with heavy ordnance.

Note.—Besides the above, two gunners attend each ammunition waggon.

Telling Off, Numbering, and Formation of Detachments in Order of March.

The several gun detachments are told off, numbered, and formed in order of march, in every respect as with Field Batteries.

Disposition of Mounted Gun Detachments.

Nos. 1 and 11 non-commissioned officers,—No. 1, the senior, on the right of the front, commands—No. 11, the junior, on the right, or right but one, of the rear rank, is the marker,—

(Light Ordnance.)

Front, 4, 12, 5, 1, Rank.
Rear, 7, 13, 6, 11, "

EXE.

(Medium Ordnance.)

Front, 4, 12, 5, 10, 1, Rank
Rear, 7, 13, 6, 14, 11, „

(Heavy Ordnance.)

Front, 4, 12, 5, 15, 10, 1, Rank
Rear, 7, 13, 6, 16, 11, 14, „

Note.—Nos. 2 and 3, are invariably mounted on the gun limber, and 8 and 9 on that of the waggon. In action, with Light, or Medium Batteries, Nos. 11, 12, and 13, and with Heavy Batteries, Nos. 10, 11, 12, and 13, continue mounted in charge of horses.

Duties and Positions of the Numbers in Action.

The duties and positions of the numbers in action are precisely the same as with Field Batteries, both with complete and reduced detachments.

Limbering Up and Unlimbering.

The guns are limbered up and unlimbered in all respects the same as with Field Batteries.

MANŒUVRES OF HORSE ARTILLERY.

Batteries of Horse Artillery, like Field Batteries, consist each of six pieces of ordnance, and are numbered and told-off in precisely the same manner except that, with Horse Artillery, the ammunition waggons, although numbered and told-off with their respective guns, constitute no part of the sub-divisions to which they are severally attached.

Note.—Notwithstanding that the waggons form no part of the several sub-divisions to which they are attached, they must, while they remain with them, conform to every movement.

EXE.

1. *A Battery—in Line, with Detachments in Front or Rear,—to Order Detachments to the Rear or Front.*

DETACHMENTS REAR—		DETACHMENTS FRONT—	
1 2 3 4 5 6	*Left about Wheel.*	1 2 3 4 5 6	*Right Incline.*
	MARCH—		MARCH—
1 2 3 4 5 6	Forward,—Left about Wheel,—Halt Dress.	1 2 3 4 5 6	Forward,—Left Incline,—Halt Dress.

2. *A Battery—in Column of Sub-Divisions,—to Form Line to a Flank.*

LEFT OF THE FRONT FORM LINE—		RIGHT OF THE REAR FORM LINE—	
2,	*Left Wheel.*	5 4 3 2 1	*Right Wheel.*
3 4 5 6	*Right Shoulders.*		
	MARCH—		MARCH—
2,	Right Wheel Up,—Halt Dress.	5,	Right Wheel,—Right about Wheel,—Halt Dress.
3 4 5 6	Left Shoulders,—Halt Dress.	4 3 2 1	Left Shoulders,—Right about Wheel,—Halt Dress.

3. *A Battery—in Line, with Detachments in Front or Rear,—to Order Detachments to the Right or Left.*

DETACHMENTS RIGHT—		DETACHMENTS LEFT—	
1 2 3 4 5 6	*Right about Wheel.*	1 2 3 4 5 6	*Left Incline.*
	MARCH—		**MARCH—**
1 2 3 4 5 6	Forward,—Right about Wheel,—Halt Dress.	1 2 3 4 5 6	Front,—Halt Dress.

4. *A Battery—in Line,—to Form Column of Sub-Divisions to a Flank.*

FORM COLUMN OF SUB-DIVISIONS IN REAR OF THE RIGHT—		FORM COLUMN OF SUB-DIVISIONS IN FRONT OF THE LEFT—	
2 3 4 5 6	*Right about Wheel.*	5,	*Left Wheel.*
		4 3 2 1	*Right Shoulders.*
	MARCH—		**MARCH—**
2,	Left Wheel,—Left Wheel Up,—Halt Dress.	5,	Right Wheel Up,—Halt Dress.
3 4 5 6	Right Shoulders,—Left Wheel Up,—Halt Dress.	4 3 2 1	Left Shoulders,—Halt Dress.

5. ***A Battery—in Line, with Detachments on the Right or Left,—to Order Detachments to the Left or Right.***

DETACHMENTS LEFT—		DETACHMENTS RIGHT—	
1 2 3 4 5 6	*Right about Wheel.*	1 2 3 4 5 6	*Left about Wheel.*
	MARCH—		MARCH—
1 2 3 4 5 6	Forward,—Right Wheel —Right Wheel Up,— Halt Dress.	1 2 3 4 5 6	Forward,—Left Wheel —Left Wheel Up,— Halt Dress.

6. ***A Battery—in Column of Sub-Divisions, with Detachments on the Right or Left,—to order Detachments to the Left or Right.***

DETACHMENTS LEFT—		DETACHMENTS RIGHT—	
1 2 3 4 5 6	*Left File.*	1 2 3 4 5 6	*Right File.*
	MARCH—		MARCH—
1 2 3 4 5 6	Right Form,—Halt Dress.	1 2 3 4 5 6	Left Form,—Halt Dress.

7. *A Battery—in Column of Sub-Divisions,—to Form Line on a Central Sub-Division.*

FORM LINE ON THE RIGHT CENTRE SUB-DIVISION—	FORM LINE ON THE LEFT CENTRE SUB-DIVISION—
2 1 } *Right Wheel.*	3 2 1 } *Right Wheel.*
4, *Left Wheel.*	5, *Left Wheel.*
5 6 } *Right Shoulders.*	6, *Right Shoulders.*
MARCH—	MARCH—
2, Right Wheel,—Right about Wheel,—Halt Dress.	3, Right Wheel,—Right about Wheel,—Halt Dress.
1, Left Shoulders,—Right about Wheel,—Halt Dress.	2 1 { Left Shoulders,—Right about Wheel,—Halt Dress.
4, Right Wheel Up,—Halt Dress.	5, Right Wheel Up,—Halt Dress.
5 6 } Left Shoulders,—Halt Dress.	6, Left Shoulders,—Halt Dress.

8. *A Battery—in Line,—to Form Column of Half-Batteries.*

FORM COLUMN OF HALF-BATTERIES IN REAR OF THE RIGHT—	FORM COLUMN OF HALF-BATTERIES IN FRONT OF THE LEFT—
4 5 6 } *Right about Wheel.*	1 2 3 } *Forward.*
MARCH—	MARCH—
4 5 6 } Left Wheel,—Left Wheel Up,—Halt Dress.	1 2 3 } Left Wheel,—Right Wheel Up,—Halt Dress.

9. *A Battery—in Line,—to Form Column on a Central Sub-Division.*

FORM COLUMN ON THE RIGHT CENTRE SUB-DIVISION—	FORM COLUMN ON THE LEFT CENTRE SUB-DIVISION—
2, *Left Wheel.*	3, *Left Wheel.*
1, *Right Shoulders.*	1 2 } *Right Shoulders.*
4 5 6 } *Right about Wheel.*	5 6 } *Right about Wheel.*
March—	**March—**
2, Right Wheel Up,—Halt Dress.	3, Right Wheel Up,—Halt Dress.
1, Left Shoulders,—Halt Dress.	1 2 } Left Shoulders,—Halt Dress.
4, Left Wheel,—Left Wheel Up,—Halt Dress.	5, Left Wheel,—Left Wheel Up,—Halt Dress.
5 6 } Right Shoulders,—Left Wheel Up,—Halt Dress.	6, Right Shoulders,—Left Wheel Up,—Halt Dress.

10. *A Battery—in Column of Sub-Divisions, or Half-Batteries,—to Form Column of Half-Batteries, or Sub-Divisions on the March.*

FORM COLUMN OF HALF-BATTERIES—	FORM COLUMN OF SUB-DIVISIONS—
1 2 4 5 } Left Shoulders.	1 2 4 5 } Right Shoulders
1 2 4 5 } Right Shoulders.	1 2 4 5 } Left Shoulders.

11. *A Battery—in Column of Divisions,—to Fo Line to a Flank.*

LEFT OF THE FRONT FORM LINE—	**RIGHT OF THE REAR FO LINE—**
3 4 } *Left Wheel.*	1 2 } *Right about Wheel.*
5 6 } *Right Shoulders.*	3 4 } *Right Wheel.*
MARCH—	**MARCH—**
3 4 } Right Wheel Up,—Halt Dress.	1 2 } Left Shoulders,—Rig about Wheel,—H Dress.
5 6 } Left Shoulders — Halt Dress.	3 4 } Right Wheel, — Rig about Wheel,—H Dress.

12. *A Battery—in Line—to Advance or Retire fro a Flank in a Column of Sub-Divisions.*

RIGHT SUB-DIVISION TO THE FRONT—	**RIGHT SUB-DIVISION T THE REAR—**
1, *Forward.*	1, *Right about Wheel*
2 3 4 5 6 } *Right Wheel.*	2 3 4 5 6 } *Right Wheel.*
MARCH—	**MARCH—**
	1, Forward.
2 3 4 5 6 } Left Wheel,—Forward.	2 3 4 5 6 } RightWheel,—Forwa

13. *A Battery—in Line,—to Advance or Retire from the Centre in a Double Column of Sub-Divisions.*

CENTRE SUB-DIVISIONS TO THE FRONT—	CENTRE SUB-DIVISIONS TO THE REAR—
3 4 } *Forward.*	3 4 } *Right about Wheel.*
1 2 } *Left Wheel.*	1 2 } *Left Wheel.*
5 6 } *Right Wheel.*	5 6 } *Right Wheel.*
MARCH—	**MARCH—**
1 2 } Right Wheel,—Forward.	3 4 } Forward.
5 6 } Left Wheel,—Forward.	1 2 } Left Wheel,—Forward.
	5 6 } Right Wheel,—Forward.

14. *A Battery—in Line, or Column of Divisions,—to Form Column, or Line on the Centre Division.*

FORM COLUMN OF DIVISIONS ON THE CENTRE—	FORM LINE ON THE CENTRE DIVISION—
1 2 } *Forward.*	1 2 } *Right Wheel.*
5 6 } *Right about Wheel.*	5 6 } *Left Wheel.*
MARCH—	**MARCH—**
1 2 } Left Wheel,—Right Wheel Up,—Halt Dress.	1 2 } Right Wheel,—Right about Wheel,—Halt Dress.
5 6 } LeftWheel,—LeftWheel *Up,—Halt Dress.*	5 6 } Right Wheel Up,—Halt Dress.

15. *A Battery—in Line,—to Advance or Retire from a Flank in Column of Division.*

RIGHT DIVISION TO THE FRONT—	RIGHT DIVISION TO THE REAR—
1, 2 } *Forward.*	1, 2 } *Inwards about Wheel.*
3, 4, 5, 6 } *Right Wheel.*	3, 4, 5, 6 } *Right Wheel.*
MARCH—	MARCH—
3, 4, 5, 6 } Left Wheel Up,—Forward.	1, 2 } Forward.
	3, 4, 5, 6 } Right Wheel,—Forward.

16. *A Battery—in Line,—to Advance, or Retire, in Column of Half-Batteries.*

RIGHT HALF-BATTERY TO THE FRONT—	RIGHT HALF-BATTERY TO THE REAR—
1, 2, 3 } *Forward.*	1, 2, 3 } *Inwards about Wheel.*
4, 5, 6 } *Right Wheel.*	4, 5, 6 } *Right Wheel.*
MARCH—	MARCH—
4, 5, 6 } Left Wheel Up,—Forward.	4, 5, 6 } Right Wheel,—Forward.

17. *A Battery—in Line,—to Form Column of Divisions to a Flank.*

	FORM COLUMN OF DIVISIONS IN REAR OF THE RIGHT—		FORM COLUMN OF DIVISIONS IN FRONT OF THE LEFT—
3 4 5 6	*Right about Wheel.*	1 2 3 4	*Forward.*
	MARCH—		MARCH—
3 4	Left Wheel, — Left Wheel Up, — Halt Dress.	1 2	RightShoulders,—Right Shoulders, — Right Wheel Up, — Halt Dress.
5 6	Right Shoulders, — Right Shoulders,— Left Wheel Up,— Halt Dress.	3 4	Left Wheel, — Right Wheel Up, — Halt Dress.

18. *A Battery—in Line or Column of Divisions,—to Change Front to the Rear by the Counter March of Half-Batteries or Divisions.*

	THE LINE WILL CHANGE FRONT TO THE REAR—		THE COLUMN WILL COUNTER MARCH—
1 2 3	*Forward.*	1 3 5	*Forward.*
	MARCH—		MARCH—
4 5 6	Right about Wheel,— Halt Dress.	2 4 6	Right about Wheel,— Halt Dress.
1 2 3	Left about Wheel,— Halt Dress.	1 3 5	Left about Wheel, — Halt Dress.

19. *A Battery—in Column of Divisions, or Sub-Divisions,—to Form Column of Sub-Divisions, or Divisions, on the March.*

FORM COLUMN OF SUB-DIVISIONS—	FORM COLUMN OF DIVISIONS—
1 3 5 } Right Shoulders.	1 3 5 } Left Shoulders.
1 3 5 } Left Shoulders.	1 3 5 } Right Shoulders.

20. *A Battery—in Line, or Double Column of Sub-Divisions,—to Form Double Column of Sub-Divisions, or Line from the Centre.*

FORM DOUBLE COLUMN OF SUB-DIVISIONS—	FRONT FORM LINE—
1 2 } *Left about Wheel.*	1, *Left Shoulders.* 2, *Right Wheel.*
5 6 } *Right about Wheel.*	5, *Left Wheel.* 6, *Right Shoulders.*
March—	**March—**
2, Right Wheel, — Right Wheel Up, — Halt Dress.	2, Right Wheel Up,—Halt Dress.
1, Left Shoulders, — Left Wheel Up, — Halt Dress.	1, Left Shoulders, — Halt Dress.
5, Left Wheel,—Left Wheel Up,—Halt Dress.	5, Right Wheel Up,—Halt Dress.
6, Right Shoulders,—Right Wheel Up, — Halt Dress.	6, Left Shoulders, — Halt Dress.

21. *A Battery—in Column of Half-Batteries,—to Form Line.*

LEFT OF THE FRONT FORM LINE—	RIGHT OF THE REAR FORM LINE—
4 5 6 *Left Wheel.*	1 2 3 *Right Wheel.*
MARCH—	MARCH—
4 5 6 RightWheel Up,—Halt Dress.	1 2 3 Right Wheel,—Right Wheel,—Right about Wheel,—Halt Dress.

22. *A Battery—in Line,—to Change Position on a Fixed Flank.*

CHANGE FRONT ON THE RIGHT FLANK, LEFT THROWN FORWARD A*** OF A CIRCLE—	CHANGE FRONT ON THE RIGHT FLANK, LEFT THROWN BACK A*** OF A CIRCLE—
1, *Right Half Wheel.* (Drivers disengage to the Right.)	1, *Left Half Wheel.* (Drivers disengage to the Left.)
2, *Right Shoulders.* 3 4 5 6 *Left Shoulders.*	2 3 4 5 6 *Left about Wheel.*
MARCH—	MARCH—
1, Halt Dress.	1, Halt Dress.
2, Left Shoulders,—Halt Dress. 3 4 5 6 Halt Dress. *(In succession.)*	2 3 4 5 6 Right Shoulders,—Left about Wheel,—Halt Dress.

23. *A Battery—in Line,—to Move to a Fla Column of Divisions or Half-Batteries.*

BREAK INTO OPEN COLUMN OF DIVISIONS TO THE RIGHT—		BREAK INTO OPEN CO OF HALF-BATTERIE THE LEFT—	
1 2 3 4 5 6	*Left Backwards Wheel.* (Drivers disengage to the Right.)	1 2 3 4 5 6	*Right Backwards V* (Drivers disengage the Left.)
	MARCH—		MARCH—
2 4 6	Forward.	3 6	Forward.
1 3 5	Left Shoulders,—Right Shoulders,—Forward.	1 2 4 5	Right Shoulders,— Shoulders,—For

24. *A Battery—in Open Column of Divisions Form Line to a Flank.*

LEFT WHEEL INTO LINE—		RIGHT WHEEL INTO L	
1 2 3	*Right Shoulders.*	1 3 5	*Forward.*
2 4 5	*Left Wheel.* (Drivers disengage to the Right.)	2 4 6	*Right Wheel.*
	MARCH—		MARCH—
1 3 5	Halt Dress.	1 3 5	Left Wheel, — R about Wheel,— Dress.
2 4 6	Halt Dress.	2 4 6	Halt Dress.

Siege, etc. Artillery.

Garrison and Siege Artillery comprize Guns, Howitzers, Mortars, and Carronades.

EXERCISE OF GUNS, AND CARRONADES.

Each detachment, for a 32-pounder gun, consists of one non-commissioned officer and six gunners,—for a 24-pounder gun, of one non-commissioned officer and five gunners,—for a 68-pounder carronade, or an 18-pounder gun, of one non-commissioned officer and four gunners,—for a 24-pounder carronade, or a 12 or 9-pounder gun, of one non-commissioned officer and three gunners,—and, for a 12-pounder carronade, or 6-pounder gun, of one non-commissioned officer and two gunners.

Note.—The complement of men for the daily service of the batteries in the attack, or defence of a fortified place, should be calculated on this basis, at two or three reliefs, according to the expected duration of the siege.

Telling Off, and Formation of Detachments in Order of March.

In all respects the same as with field guns.

Duties and Positions of the Numbers in Action.

No. 1, directly in rear of the gun, points, commands, and assists to run the gun up,—2, on the right of the gun, in line with the muzzle, sponges, runs up, and elevates,—3, in line with the muzzle, on the left of the gun, loads, runs up, and elevates,—4, on the right of the gun, clear of the truck, or wheel, and in line with the breech, serves the vent, runs up, traverses, and primes,—5, in line with the breech, clear of the truck, or wheel, on the left of the gun, runs up, traverses, and fires,—6, attends at the magazine, serves 3 with ammunition, and assists to run the gun up,—7, under cover of the merlon, assists to run the gun up.

Note.—If the gun be mounted en barbette, the several numbers take post en échelon outside the platform. When not immediately employed in working the gun, they take post under cover of the épaulment.

Duties in Action with Reduced Numbers.

Distribution of the Duties.

1	2	3	4	5	6
C.R.V.P.F.	S.R.E.T.	L.R.E.A.T.			
C.R.V.P.	S.R.E.T.	L.R.E.T.	R.A.F.		
C.R.	S.R.E.	L.R.E.	V.R.T.P.	R.T.F.A.	
C.R.	S.R E.	L.R.E.	V.R.T.P.	R.T.F.	A.

Note.—The numerals in the first line, have reference to the duties of the several numbers, as explained in the preceding article. The small capitals under them, specify the additional duties required of each number, according to the strength of the detachment. That is, with only three men to each gun,—No. 1, not only points, commands, and assists to run the gun up, but serves the vent, primes, and fires,—No. 2, sponges, runs the gun up, elevates, and traverses,—and No. 3, loads, runs the gun up, elevates, serves ammunition, and traverses.

EXERCISE OF MORTARS AND HOWITZERS.

Each detachment, for a 13-inch mortar, or 10-inch howitzer, consists of one non-commissioned officer and five gunners,—for a 10-inch mortar, or an 8-inch howitzer, of one non-commissioned officer and four gunners,—for an 8-inch mortar, of one non-commissioned officer and three gunners,—and for the 5½ and 4⅖-inch mortars, of one non-commissioned officer and two gunners each.

Telling off, and Formation of Detachments.

Precisely the same, in every respect, as for guns and carronades.

Duties and Positions of the Numbers in Action.

No. 1, directly in rear of the mortar, points, commands, and serves the vent,—2, on the right of the bed, in line with the muzzle, sponges, uncaps the fuze, assists 3, 4, and 5, to put in the shell, runs up, and traverses,—3, in line with the muzzle, on the left of the bed, loads, assists 2, 4, and 5, to put in the shell, runs up, and traverses,—4, on the right of the mortar, covering 2, and in line with the vent, prepares the shells, assists 5 to bring them up, and put them into the mortar, runs up, traverses, and primes,—5, in line with the vent, on the left of the mortar, assists 4 to prepare the shells, bring them up, and put them into the mortar, runs up, traverses, and fires,—6, attends at the magazine, supplies 3 with cartridges, cuts, and fixes the fuze.

Note.—In serving howitzers, the duties and positions of the several numbers, are precisely the same as with guns, and carronades; 4 and 5 bringing up the shells, which are put into the muzzle by 3 and 4, and home, by 2; No. 6 cuts, and fixes the fuze.

Duties in Action with Reduced Numbers.

Distribution of the Duties.

1	2	3	4	5
C.V.A.B.R.P.	S.L.R.E.T F.			
C.V.P.	S.R.E.T.	A.B.L.R.E.T.F.		
C.V.P.	S.R.E.T.	A.L.R.E.T.	B.F.	
C.V.	S.R.E.T.	A.L.R.E.T.	R.B.P.	R.B.F.

Note.—The explanation of this table is the same as that under the head of guns and carronades. The additional letter B specifying the numbers that assist in bringing up the shells. No. 2, puts them into the 8, 5½, and $4\frac{2}{5}$-inch mortars.

Various Machines.

The several detachments are numbered and told off, in this Branch of the Exercises, in precisely the same manner in every respect as in the two preceding Branches, except that, in the Exercise of the Devil Carriage, the odd numbers are on the right side, and the even numbers on the left.

EXERCISE OF THE TRIANGLE GYN.

The complement of men for the service of a triangle gyn, is usually one non-commissioned officer and ten gunners.

3. Carries at the foot of the left cheek, works the left hand lever, keys and unkeys the left hand cap-square of the gun-carriage, and assists to run the carriage up or back.

5. Carries at the top of the left cheek, works the left centre lever, and assists to run the carriage up or back.

7. Carries the levers and hand-spikes, assists number 6 in passing the fall round the windlass, and holds on next to him.

9. Carries at the top of the pry-pole with the slings, fid, and trucks, holds on the fall behind number 8, and coils it up as it comes off.

11. Assists in carrying the blocks and fall, reeves and unreeves the triple-block, assists in slinging

2. Carries at the foot of the right cheek, works the right hand lever, keys and unkeys the right hand cap-square of the gun-carriage, and assists to run the carriage up or back.

4. Carries at the top of the right cheek, works the right centre lever and assists to run the carriage up or back.

6. Carries the windlass, passes the fall round it, holds on, makes it fast, eases off, and lowers the gun.

8. Carries at the foot of the pry-pole, with the slings, fids, and trucks, and holds on next to number 7.

10. Assists in carrying the blocks and fall, reeves and unreeves the double block, assists in slinging

the gun, and steadies it at the muzzle.

the gun, and steadies it at the cascable.

EXERCISE OF BELL'S GYN.

The complement of men for working this gyn is, one non-commissioned officer and six gunners.

3. Runs the carriage up or back, assists 6 to sling the gun, turns the winch, assisted by 5, opposite to him, or makes fast and hauls upon the rope, which is passed round the handles of the winch.

2. Runs the carriage up or back, assists 7 to sling the gun, turns the winch, assisted by 4, or holds on upon the rope.

5. If necessary, runs the carriage up or back, and assists 3, at the winch.

4. Performs similar duties to 5, on his own side.

7. Assisted by 2, slings and unslings the gun at the chase, and steadies it at the muzzle.

6. Assisted by 3, slings and unslings the gun near the first reinforce ring, places the bed and quoin, and steadies the gun at the cascable.

EXERCISE OF THE GIBRALTAR GYN.

The complement of men required to work this gyn, is one non-commissioned officer and six gunners.

3. Runs the carriage up and back, assists 2 to heave the windlass round, standing outside the gyn fronting him, and assists 6 to sling the gun.

2. Runs the carriage up and back, heaves the windlass round, standing inside the gyn, fronting number 3, and assists 7 to sling the gun.

5. If necessary, runs the carriage up or back, assists

4. Runs the carriage up or back, holds on the fall

in holding on the fall, stoppers and un-stoppers it when it requires shifting.

7. Assisted by 2, slings and unslings the gun at the chace, and steadies it at the muzzle.

when the gun is being raised, makes the fall fast, and lowers the gun.

6. Assisted by 3, slings and unslings the gun near the first reinforce-ring, places the bed and quoin, steadies the gun at the cascable, and overhauls the tackle.

EXERCISE OF THE SLING CART.

The compliment of men is one non-commissioned officer and six gunners.

3. Has charge of the left lever, and when necessary, assists to skid the gun.

5. Assists 2, at the lever and skidding, and, when the gun is to be lashed, assists in raising the breech.

7. Assists 3 at the lever, slings and unslings the gun, and lashes it to the pry-pole.

2. Has charge of the right lever, and, when necessary, assists to skid the gun.

4. In like manner assists 2, and, when the gun is to be lashed, assists in raising the breech.

6. Assists 2 at the lever, assists in slinging and unslinging the gun, and lashing it to the pry-pole.

The non-commissioned officer puts in and takes out the pauls.

EXERCISE OF THE DEVIL CARRIAGE.

The complement of men for working this carriage is one non-commissioned officer and ten gunners.

3. Has charge of a drag-rope, assists to haul the perch up and down,

2. Has charge of a drag-rope, assists to haul the perch up and down,

bears the muzzle of the gun down, and, when the breech is raised, puts the lever into the muzzle.	assists 3 in bearing the muzzle down, and, when the gun and carriage are lashed on, puts up the skid.
5. Steadies the gun-carriage when raised on its breast transom, and, with the long guy-rope, lashes its front axle-tree to the devil-carriage.	4. On his side, performs similar duties to those of number 5.
7. Slings the gun, lashes the breech to the perch, assists in limbering up and unlimbering, and slings the gun-carriage.	6. Performs similar duties to number 7.
9. Has charge of one of the short guys, assists in unlimbering and limbering up, and in hauling the breech of the gun up to the perch, lashes the hind axle-tree of the gun-carriage to the devil-carriage, and fixes the long guy-rope to the iron eyes at the end of the perch.	8. Performs similar duties to number 9.
11. Assists in unlimbering and limbering up, and in hauling the breech of the gun up to the perch, lashes, with the short guy-ropes, the rear axle-tree of the gun carriage to the devil-carriage, and fixes the short-guy ropes to the ring under the perch.	10. Performs similar duties to number 11.

Fascines,—*Battery,*—*Fortification,*—*Gravity.*
Weight, Dimensions, etc., of Fascines, Gabions, and Hurdles.

DIMENSIONS, ETC.	Gabions.	Fascines.	Hurdles.	OBSERVATIONS.
FASCINES.				Fascines are prepared on small trestles formed by driving strong stakes obliquely into the earth, by pairs so, as to cross each other in contact, at right angles, or nearly so, at about 2 feet 6 inches from its surface. Each stake should be 6 feet 6 inches long, by about 2 inches in diameter: and, that they may not separate under the operation of the choaker, they must be firmly pinned or lashed together with spunyarn, at the point of crossing. The number of these trestles required, must of course, depend on the intended length of the fascines. They are usually placed at from 3 to 4 feet apart (in a right line, and on an even surface), according to the nature and quality of the brushwood. In the preparation of Gabions, care must be taken to employ an odd number of pickets for the warp, whatever may be their dimensions and distance apart, otherwise, the strength of the web will not be uniform throughout the circumference.
Length	..	18·00	..	
Diameter	..	·75	..	
GABIONS.				
Height	3·00	..	..	
Diameter	1·50	..	..	
HURDLES.				
Height	..	..	3·00	
Breadth	..	..	2·50	
MATERIALS.				
Pickets, Length	3·50	4·00	3·50	
Diameter	·06	·16	·06	
Number	9·00	6·00	6·00	
Rods, Length				
Diameter	·04	·06	·04	
Gads, Length	..	5·00	..	
Diameter	..	·04	..	
Number	..	12·00	..	
Dist. apart	..	1·50	..	
Stakes, Length	..	6·00	..	
Diameter	..	·13	..	
Number	..	2·00	..	
IMPLEMENTS.				
Bill-Hooks	2	2	1	
Knives	2	3	1	
Handsaws	..	1	..	
Mallets	1	2	1	
Choakers	..	1	..	
Measuring Rods	1	1	1	
Men required	3	4	2	
Time „ (Hours)	¾	½	½	
Weight	45	140	13	

OBSERVATIONS ON FASCINES, GABIONS, AND HURDLES.

In general no precise rules can be laid down for the dimensions of gabions, hurdles, or fascines. These must depend on the nature and quality of the materiel of which they are to be made, the season at which that materiel is cut, and the uses to which they are to be applied.

Birch, willow, and hazel, are the best woods for this work. Oak, generally speaking, is too dense,—it is, however, by far the best materiel for the pickets, gads, and understakes.

The intrinsic density of the wood to be employed is matter for consideration, as is also the season at which it was cut. Fascines, gabions, or hurdles, made in the spring, or summer, from fresh cut brushwood, will, of course, be much heavier than others of the same dimensions, made from the like materiel cut in the autumn or winter.

It is also of importance to bear in mind, in fixing the dimensions of fascines, that cylinders, of equal lengths, are, to each other, as the squares of their circumferences, and, consequently, that any excess in their diameters, beyond what is absolutely required, will not only inconveniently increase their weight, but also necessitate a useless expenditure of both time and materiel in their preparation.

Fascines are made of various dimensions,—usually from three to eighteen feet in length by six, or nine inches in diameter. The longer, the better, as the strength of a revetment is increased in proporton as the number of joints is diminished.

It is a good general rule, in regard to economy, both of time and materiel, to make all fascines eighteen feet long, in the first instance. If the gads, or bands, be properly disposed a fascine of this description can be afterwards readily cut into lengths of three, six, or nine feet, as occasion may require.

The average weight of a fascine of this length, nine inches in diameter, will be about 140 lbs.

Gabions, three feet in height, by eighteen, or twenty inches in diameter, have been found, after repeated trials, to be the most convenient for the sap, and indeed for every description of work. They are easily made, and are found to be perfectly manageable by men under fire.

The average weight of a gabion, three feet in height, by twenty inches interior diameter, made of willow, will be about 45 lbs.

Large gabions, five feet six inches in height, by four feet eight inches in diameter, are used as sap rollers. They are troublesome to make, and require two men to carry them.

There is also a smaller description of gabion, in the form of the frustum of a cone. These are generally made one foot in height, twelve inches in diameter at the top, and nine inches at the bottom. They are used, at sieges, to form loop-holes on the crests of the parapet.

Hurdles are made of various dimensions, according to the uses to which they are to be applied—generally about three feet in height, by two feet six inches in breadth. Of these dimensions, connected by threes in the form of a prism, they constitute a kind of triangular gabion, and are very convenient in the construction of the flying sap,—especially when the materiels for the trenches, etc., are prepared at a distance from the place.

Gabions of this description, when made of sufficient dimensions, are also very useful in lining the cheeks of embrazures, forming field magazines, and reveting traverses, and other works. They form a more solid revetment, especially if arranged in contact side by side, than either the ordinary gabions, or fascines; and, when the means of transport are difficult to be procured, they possess this further important advantage, that they can be packed into the smallest possible space.

FLINTS.—*Artillery,—Cartridges.*

Flints are allotted in the proportion of one to ten—that is, one flint is allowed with every ten cartridges. The most transparent, and free from veins are considered the best.

During the late war, flints were packed in half-barrels. The present practice is, to pack them in strong canvass bags, for transport on bât horses, or mules, and in deal boxes for carriage transport.

In each of these bags, 200 musquet, 400 carbine, or 750 pistol, flints are packed; and, in each box, five bags, or 1000 musquet, 2000 carbine, or 3750 pistol flints.

The average weight of each box, containing either of these quantities, is about 50 lbs.

FLUIDS.—*Bridges,—Fortification,—Gunnery.*

Fluids are either elastic, or non-elastic. Elastic, when they admit of compression, as the atmosphere—non-elastic, when incompressible, as water.

Every fluid, elastic or non-elastic, is regarded, in the aggregate, as a collection of infinitely small spheres, possessing the power of moving on, and over, each other, in every direction, free of friction.

ON THE RESISTANCE OF FLUIDS TO MOVING BODIES.

If two bodies move through a fluid, with unequal velocities, the number of particles of the fluid displaced by each will be proportional to the with which it moves; and the force with whic particle of the fluid re-acts against the body w be proportional to the said velocities respectively sequently the resistances which the bodies exp in moving through the fluid, will be proporti the squares of their velocities.

When a body moves through a homogeneou at rest, the resistance it experiences will evide the same as that which it would experience if tl were at rest, and the fluid moved against it velocity equal to that of the body in the form And since the pressure, in every direction, at t of a vertical filament of fluid, is equal to the of that filament, and the velocity with wh particles of the fluid would move off laterally duced by that pressure, which, by the laws of dynamics, is equal to the velocity acquired by ticle falling through the height of the filament lows that any surface opposed to this lateral will sustain a pressure equal to the weight o ment of the same height as that which is du velocity of the particle. Therefore, the a pressure experienced by a plane surface, parallel to itself through a fluid at rest, is equa weight of a column of the fluid of which the equal to the surface opposed, and height equa space through which a body must fall vertic acquire a velocity equal to that with which tl moves.

This pressure would be experienced by a p cylinder, moving through a fluid, in the dire its axis, or when its extremity is perpendicula line of motion. And, by the theory of forces be found, that if the plane surface, or extremit body, be inclined to the line of motion, the p of the fluid against it, is to the pressure aga equal surface, perpendicular to the line of motion, as the cube of the sine of inclination is to the cube of radius.

If a pyramid or cone, or a prism or cylinder, terminating in a pyramidal or conical surface, move through a fluid in a direction parallel to its axis, with its vertex in front, the pressure which the body would experience, is to the pressure on a plate of an area equal to that of the base of the pyramid or cone, as the square of the sine of the inclination of the slant side to the line of motion, is to the square of radius. Therefore, if a cylinder, terminating in a cone, a section of which, made by a plane passing through the axis, is an equilateral triangle, be made to move through a fluid, the resistance it would experience is one-fourth of that which would be experienced by the plane extremity of the same cylinder.

When a cylinder, terminated by a hemisphere, moves in the same manner through a fluid, the resistance on the spherical surface would be equal to half of that which would be experienced on a circular plate, equal to the base of the hemisphere.

By these principles, the amount of the resistance experienced by a shot in moving through the atmosphere, with any given velocity, may be theoretically determined. But the inertia of a shot, in motion, being a force which opposes the pressure of the air upon it, and this inertia being proportional to the mass or weight of the shot, it follows that the retardation experienced by the shot in moving through the air, is directly proportional to the resistance, and inversely proportional to the weight of the shot.

These circumstances are independent of the pressure arising from the condensation of the air in front, and that arising from the vacum in rear of the shot, when moving with great velocity; on which accounts, and probably for many other reasons, the results of experiment are very different from those of theory.

From the experiments made by Dr. Hutton, on the resistance experienced by different bodies passing through the air, with velocities of from 3 to 20 feet per second, the following results have been obtained.

Two hemispheres, the diameters of which were 4·75 and 6·625 inches respectively, moving with their flat surfaces forward, experienced resistances which were nearly proportional to those surfaces, while the velocity was less than 12 feet per second; but the resistances were in rather a higher ratio when the velocity was greater.

The resistances experienced by the same surfaces, were nearly proportional to the 2·1 power of the velocity.

When the three following bodies were employed:— viz., a cylinder, the length and diameter of which were each equal to 6·625 inches; a hemisphere, the diameter of which was 6·625 inches; and a cone, having an altitude and diameter of base, each equal to 6·625 inches, it was found,—

1. That the resistance experienced by the flat ends of the cylinder, hemisphere, and cone, were to each other as the numbers 1, 1·0105, 1·021 respectively.

2. That the resistance experienced by the flat surface of the hemisphere, was to that experienced by the convex surface, as 1 to ·413.

3. That the resistance experienced by the base of the cone, was to that experienced by the vertex, as 1 to ·433.

So that a cone, a section of which, through the vertex, forms a right angled isosceles triangle, experiences greater resistance than a hemisphere, the diameter of which is equal to that of the base of the cone. By theory it should experience less resistance. And the resistance on the base of such a cone, is to that on the vertex, as radius is to the sine of the angle of inclination of the side to the axis. By theory, as above, it should be as the square of radius, to the square of the sine of the inclination.

The resistance on the flat surface of a hemisphere, is to that on the surface of a whole sphere, of equal diameter, as 1 to ·4305. By theory it should be as 1 to ·5.

The resistance on the convex surface of a hemisphere, is to that on the surface of a whole sphere, of equal diameter, as 1 to 1·042.

The resistances experienced by bodies are different when their fronts are equal and similar, but the opposite parts are of different forms.

Lastly. The resistances experienced by plane surfaces, are greater than the weight of a column of air of a base equal to the area of the surface, and height equal to that which a body must fall through to produce a velocity equal to that of the body in motion. The resistance experienced by the flat surface of the cylinder above-mentioned, moving with a velocity of 20 feet per second, was, by experiment, found equal to 2·528 ounces. By theory it should be 1·7904 ounces; so that the resistance is really equal to the weight of a column of air of the same base, and a height equal to 1·41 times that required by theory. With a velocity of 10 feet per second, the resistance, by experiment, is ·565 ounces; by theory it is ·448 ounces; so that the actual height of the column is 1·26 times the height required by theory. The proportion is nearly the same, when the velocity is anything less than 10 feet.

According to the experiments of Borda, the impulse of wind against a plain surface equal to one square foot, when moving with a velocity of one foot per second, is equal to $\frac{1}{500}$ part of a pound avoirdupois.

By other experiments, it has been found, that when a flat plate moves through water, with a velocity of one foot per second, the resistance is equal to 1·75 pounds avoirdupois on each square foot of surface.

When the body is of a cubical form, the resistance against the surface in front, when the velocity is one foot per second, is equal to 1·5 pound avoirdupois on each square foot of that surface; and when the length of the vessel is three or four times its breadth, the resistance on each square foot is about 1·33 pound.

Then, supposing the resistances to be proportional to the squares of the velocities of the body, or of the fluid, the resistance due to any other velocity may be found.

ON THE PRESSURE OF FLUIDS AGAINST WALLS.

Since the pressure on any horizontal section of a vessel containing a fluid, is equal to the weight of the column of fluid above the section, and that the lateral pressure of a filament of fluid is equal to its vertical pressure; the pressure at any point on the vertical side of the vessel is proportional to the depth of that point below the upper surface of the fluid.

Therefore, if a vertical section of a vessel be taken, the whole pressure against the side of the section may be represented by the area of a right angled triangle, of which the altitude is equal to the height of the fluid above the bottom, and the base equal to a line expressing the pressure on any point of the bottom; this is equal to half the parallelogram representing the vertical pressure of a lamina of fluid of equal base and altitude. Consequently, if the vessel be rectangular, and the area of the vertical side equal to the area of the bottom, the pressure against that side will be equal to half the pressure on the bottom; and it follows, that the pressure of a fluid against any upright surface, is equal to half the weight of a column of the fluid, the base of which is equal to the surface pressed, and the altitude, to the depth of the fluid.

When any surface, turning on a horizontal joint, coinciding with its upper edge, is pressed by a fluid, moving against it horizontally, the action of the fluid in turning the plane, is analogous to the action of gravity in making it vibrate upon the same joint. Therefore, the pressure of the fluid on the whole surface is the same as the action of an equal force applied, horizontally, at the centre of oscillation of the plane; that is, if the plane be rectangular, at a point which is below the joint as much as two-thirds of the vertical height of the plane.

ON THE VELOCITIES OF EFFLUENT FLUIDS.

If a very small orifice be made in the bottom of a vessel containing a fluid, the pressure on a particle of the fluid at the orifice is equal to the weight of a vertical filament of the fluid immediately over the particle, and this is equal to the sum of the actions of gravity upon all the particles in that filament. But if a particle fall through a height equal to that of the filament it is acted upon at every instant of its descent by a force equal to the weight of the particle, and the sum of all those actions of gravity is equal to the weight of the filament; therefore, the velocity with which a particle will issue from the orifice, will be the same in both cases. It follows that the velocity with which the fluid issues from a very small orifice in the bottom, or in the side close to the bottom, is equal to that which a body would acquire by falling through a height equal to that of the column of fluid above the orifice; and if orifices were made at different depths in the side of the vessel, the velocities with which the fluid issues would be proportional to the square roots of the depths of the orifices; because, the velocities which bodies acquire by gravity in falling, are proportional to the square roots of the spaces descended. But when the orifice in the bottom or side of a vessel is large, the fluid converges towards the axis of the stream after quitting the orifice, and forms a contraction in the stream, the area of which is to the area of the orifice, as 1 to $\sqrt{2}$. Therefore, because equal quantities of fluid pass through unequal sections of the same pipe in equal times, it follows that the velocity in the contraction is to the velocity in the orifice as $\sqrt{2}$ to 1. And the velocity in the contraction is equal to that acquired by a body falling through the whole height of the fluid; therefore, the velocity in the orifice will be equal to that acquired by falling through half the height of the fluid.

It has been found, by experiment, that the quantities of water discharged in equal times through orifices of different sizes, and at the same depths in the vessel, are proportional to the areas of the orifices, or to the squares of their diameters. And it may be proved, from the principles before stated, that a cylindrical or prismatic vessel, if kept constantly full, will discharge through an orifice twice as much water as it contains, in the time that it would take to empty itself through the same orifice. Also, that if a notch or sluice in the form of a rectangle be cut vertically in the side of a vessel full of water, the quantity of water flowing through it will be equal to two-thirds of the quantity which would flow in the same time through an equal orifice placed horizontally at a depth equal to that of the bottom of the vertical notch, the vessel being kept constantly filled to the level of the top of the same notch.

By the experiments of M. Bossut, it appears that when water flows through a pipe 30 feet long and 1·25 inches in diameter, the velocity at the mouth of the pipe is only half of that at the orifice; and that when the pipe is 180 feet long, and of the same diameter as before, the velocity at the mouth is only equal to one-sixth of that at the orifice, the loss of velocity being caused by the friction within the pipe. And he concludes that the quantities discharged through pipes of equal diameters in equal times, and with the same head in the reservoir, are inversely proportional to the *square roots* of the lengths of the pipes nearly.

FORTIFICATION.—*Artillery.*—*Battery.*—*Mine.*

Fortification is either natural or artificial, offensive or defensive.

Mountains, rivers, defiles, and, in general, every accident of the ground, calculated to impede or facilitate an offensive or defensive operation, are natural fortifications. By artificial fortification, is understood, any obstacle, or cover, raised, for a like purpose, by the labour and ingenuity of man.

Fortification is also further subdivided into permanent, and temporary, or field fortification.

Permanent Fortification.

Fortified places are military positions, permanently intrenched. The value of such a position is, cæteris paribus, inversely, as the strength of its garrison, and directly, as the time required for its reduction. Defensive permanent fortification may therefore be defined, the art of intrenching a given site, or position, in such a manner that the weakest possible garrison shall be able to sustain the longest possible siege.

Engineers have proposed and adopted various systems of fortification, or modes of fortifying, in each of which is to be considered the tracé, or outline, the command, and the relief. Of these various systems, that of Cormontaigne, or rather that which is known as the First System of Vauban, improved and enlarged by that eminent engineer, is generally considered the least defective. It combines, in a higher degree than any other, the essential principles of the art, with simplicity of arrangement.

By the tracé, or outline of a system of fortification, or mode of fortifying, is understood its ground plan, or horizontal projection,—by the command, its vertical elevation, above the plane of site, or ground on which it is erected, or the vertical elevation of one of its constituent parts, above another in its front,—and, by the relief, the absolute height of any part of the system which is preceded by a ditch, measured from the lowest point of its surface.

If the position is detached, or isolated, or if the proposed defences are to enclose it on all sides, the first operation, in laying down the tracé, must be to embrace the site, or ground to be fortified, in a polygon,—inferior or superior, regular or irregular, according as the one figure, or the other, will occupy it to the greatest advantage. On either side of this primitive figure,—the length of which must depend on the nature and range of the arms to be employed in its defence, that is to say, it should not be less than two hundred and sixty, nor much exceed three hundred and eighty yards,—is constructed a portion of the principal intrenchment or main enclosure,—called a fortified front,—comprising two demi-bastions, and an intermediate curtain. Each side therefore of the circumscribing polygon, or primitive figure, is the base of construction, of that particular portion of the works erected upon it, and the flanked angles of the bastions severally correspond or coincide with its saliants.

The nature of the polygon by which the site or position is to be embraced, is an important subject for consideration. It exerts a powerful influence on the defence,—the relative strength of each individual front being in the direct ratio of the magnitude of its angles. In the higher polygons, especially in those superior to the heptagon, the flanked angles of the bastions become proportionably more and more obtuse, so that a besieger finds it difficult, in the same *proportion*,—in some cases impossible,—to enfilade the faces of those works, and the action of the collateral ravelins, is, at the same time, so direct on the flanks and rear of his approaches, that he is compelled to silence their fire, before he can venture to attack the intermediate bastion, or attempt to crown the glacis or to effect a lodgment in the covered-way. If the magnitude of the angles of the polygon, or of any portion of it, be such that two or more fortified fronts can de disposed in nearly a right line, these advantages will be still further improved; and if, from any irregularity in the ground, several fronts can be traced on a concave line, the result will be decisive in favour of the defence.

Both Vauban and Cormontaigne, to determine the position of the lines of defence, bisect the base of construction by a perpendicular. Cormontaigne, in his system, makes the length of the perpendicular, measured from the point of bisection to its foot, or interior extremity, equal to one-sixth of the base. Vauban varies the length of the perpendicular. He makes it equal to one-eighth, one-seventh, or one-sixth, of the base, according as the figure to be fortified is a square, a pentagon, or any superior polygon. Engineers in general approve of Vauban's method of regulating the length of the perpendicular, provided it be not applied to polygons superior to the hexagon. It is not so generally approved when applied to the superior polygons. It admits of no variation in the length of the flanks, and, consequently, as some engineers conceive, unnecessarily restricts their action, in opposing the construction of the besiegers' counter-batteries.

The lines of defence are drawn, both by Vauban and Cormontaigne, from the angles of the polygon, or extremities of the base of construction, through the foot of *the perpendicular*, and on these lines they trace the faces of the bastions. Vauban makes the length of each face of his bastion equal to two-sevenths of the side of the polygon, or base of construction. Cormontaigne, that he may increase their interior capacity, makes each face equal to one-third of the base, and, adopting Pagan's principle, draws his flanks perpendicular to the opposite lines of defence. In Vauban's system, each flank is the chord of an arc described from the shoulder, or, according to some authors from the saliant of its opposite bastion as a centre, with a radius equal to the distance between that point and the shoulder of the collateral bastion. The curtain completes the outline of the main enclosure. It connects the collateral flanks, by a right line, passing through the points in which they respectively intersect the opposite lines of defence. By Cormontaigne's construction the faces of the bastions are defended by a grazing fire;—by Vauban's, they are defended by a moderately plunging fire. Vauban's method is that generally preferred. The defence which it provides for the ditch is not less effective than that provided by the method of Pagan and Cormontaigne, and it possesses this additional advantage,—the fire of his flank searches into the breach in the face of the opposite bastion, and takes its assailants in reverse.

Engineers are divided in opinion as to the proper dimensions to be given to the main ditch. Its excavation must furnish a sufficient supply of earth for the construction of the elevated portions of the intrenchment. In other words, the area of its vertical section must be equal to the aggregate area of a corresponding section passing through the rampart, parapet, and glacis, while its breadth is sufficient to admit of an effective musquetry fire, from the face of the bastion on the opposite counterscarp, without weakening too *much the* crest of its parapet. Cormontaigne, in his *system*, makes the breadth of the ditch at the saliant of the bastion somewhat less than the length of the opposite flank, minus the breadth of the covered-way, and draws the branches of the counterscarp, from the rounding, to the angle which the crest of the parapet, of the flank, forms with that of the face of the bastion. By this construction, the flank not only effectually defends the ditch, in its front, even to the grazing of the counterscarp itself, but, at the same time, it is enabled, by its extent and the superiority of its fire, to meet and oppose the besiegers, in their endeavours to establish counter-batteries, on the terre-plein, of the covered-way, or crest of the glacis.

Next to the main enclosure, the tracé of which is explained in the preceding paragraphs, the principal element in Vauban's system, as also in Cormontaigne's is, the ravelin. By its position in the re-entering angle, formed by the branches of the counterscarp, of the main ditch, the ravelin covers the curtain the flanks and the shoulders of the bastions, and by the fire of its faces defends the ground in front of their saliants. Vauban's tracé of the ravelin is inferior to that of Cormontaigne. He places its saliant at the intersection of the perpendicular produced, and an arc described from one extremity of the curtain, as a centre, with the portion of the line of defence, intercepted between that point and the flank of the opposite bastion, as a radius, and directs its faces to points taken on those of the bastions, at about eleven yards from their respective shoulders. Cormontaigne directs the faces of his ravelin to corresponding points at about thirty yards from the shoulders of the respective bastions, and places its saliant at the vertex of an equilateral triangle, erected on the right line joining those two points. It is evident that the curtain and the flanks and shoulders of the bastions are much better covered by Cormontaigne's than by Vauban's ravelin, and it is *also equally* evident that, in proportion as it is more capacious, it can be more effectually retrenched. Notwithstanding these advantages, however, and the commanding defence which Cormontaigne's ravelin affords, to the ground in front of the saliants of the bastions, its tracé is susceptible of farther improvement. Its flanked angle being more acute, its faces are more exposed to the fire of the besiegers' enfilading batteries than are those of Vauban's; and its ditch, which is generally about sixty feet broad, inconveniently uncovers a corresponding portion of the face, of each bastion, towards its centre. By Cormontaigne's construction of the ravelin, therefore, the besieger is enabled to avail himself of his counter-batteries, established on the branches, or terre-plein, of its saliant place of arms, to breach the main enclosure, and this advantage increases in direct proportion to the saliancy or projection of the ravelin into the country.

Vauban and Cormontaigne both retrench the ravelin. Vauban's first retrenchment consisted of a simple loop-holed wall, in the form of a lunette, with a narrow ditch in its front. He subsequently increased the breadth of the ditch, and added an earthen parapet. Even in this improved state its tracé is defective. Cormontaigne retrenches his ravelin by a substantial redoubt, to which, in fact, the ravelin itself is merely a counterguard. The ditch of Vauban's retrenchment is undefended by any direct fire,—that of Cormontaigne's is defended by the faces of the bastions, to the interior extremities of which its scarp revetment is directed. It is also to be observed, that the flanks of Cormontaigne's retrenchment, each of which is of sufficient extent to contain three guns, independently of those placed in the casemates beneath its parapet, so effectually defend the passage of the main ditch that it is next to impossible that an enemy can venture to assault the body of the place, until both the ravelin *and its* redoubt are in his possession. Neither the ditch of the ravelin nor that of its redoubt is equal in depth, to that of the main enclosure,—the ditch of the redoubt has the least depth of the three. The counterscarps of these works are drawn parallel to their respective escarps, and each demi-gorge produced passes through the interior extremity of the face of the ravelin and the flanked angle of the collateral bastion. By this construction the faces of the ravelin not only defilade the passages from the caponière into the main ditch, but at the same time cover the terre-plein, and flanks of the redoubt, from the fire of the counter-batteries, established on the branches, or terre-plein, of the saliant places of arms of the opposite bastions.

In the main ditch, immediately before the curtain, is the tenail. Vauban is the author of this work. It covers the curtain,—except towards its extremities,—the postern constructed under its centre, and the flanks and shoulders of the adjoining bastions. It defends by a closer and more grazing fire than the curtain, the ditch, and the terre-plein of the opposite ravelin, or that of its redoubt; it renders an attack on the gorges of those works a hazardous operation; and, finally, it facilitates the retreat of the troops, by which they were defended. In his original tracé Vauban gave to this work the form of a fortified front, and so regulated its relief that the crest of its parapet was about four feet beneath a line of fire, from the interior extremity of the flank of one bastion to the probable place of a breach in the face of the one opposite. He subsequently abandoned this outline, and adopted that of a simple re-entering angle, which he traced on the lines of defence. Cormontaigne still further improved on this construction. He cut off the angle formed by the faces, and added a curtain parallel to that of the place.

If the ditch be dry the communication between the

place and the ravelin must be covered by a
ère,—that is, by a kind of double covered-way.
montaigne makes great use of this defensive
his system. He constructs demi-caponières
the main ditch, and the ditch of the ravelin, t
and defend the communications with the re-e
places of arms. He also covers the postern,
flank of the redoubt, of the ravelin, by a demi-
ère thrown across its ditch, immediately in f
the interior extremity of each face; and, as a
protection to the posterns, and, at the same
cover the passages between the flanks of the
and the extremities of the tenail, he constructs
caponière across the main ditch, on the prolo
of each face of the ravelin. If the ditch be
difficult to establish and preserve the commu
between the place and the several out-works.
case, the communications are maintained by
on trestles, piles, or boats, or by boats alone.
are both expensive and inconvenient: they
constant repairs, and it is impossible to preserv
after the arrival of the enemy on the crest of the
Dry ditches are, on this account, preferable to
the operations of an active defence they posse
numerous other advantages.

Beyond the main ditch, and the ditch of the
is the covered-way, and its parapet, the glaci
covered-way envelopes the ditch, covers the
revetment, and ensures to the garrison a cover
munication along the counterscarp, and place
dezvous preparatory to any external operati
also defends the ground in its front, by a cl
grazing fire; and, in case of need, covers and
tates the retreat of the sorties. Its branc
drawn parallel to the counterscarp, except
rounding, opposite the flanked angles of the

and ravelin, or saliant places of arms; the re-entering places of arms are cut out of the glacis, and exercise an important influence on the defence. Each demi-gorge should be from forty-five to sixty yards long, and the faces should form angles of about one hundred degrees, each, with the adjoining branches of the covered-way. Vauban re-trenched the re-entering place of arms by a tambour, or by an earthen redoubt, of feeble profile, and interposed traverses, across the terre-plein of the covered-way, to prolong its defence, and to diminish the otherwise destructive effects of the besiegers' ricochet and enfilading batteries.—Cormontaigne enlarged its interior capacity, and improved the construction and tracé of the redoubt. He defiladed its faces, directing them to the re-entering angles of the glacis, supported its scarps by solid revetments, and added a flank to each face, to command the main ditch and the ditch of the adjacent ravelin.

Engineers, subsequent to Vauban and Cormon-
igne, place the crest of the parapet of the covered-
ay in the same horizontal plane, or plane of defile-
ent, as the tablette or summit of the escarp revet-
nt; and oppose the operations of the besiegers, even
er they have arrived on the glacis, by a simultaneous
l plunging fire from the interior defences. It is on
se principles that they determine the command of
ravelin, on which that of the body of the place is
ndent, so, that the fire of its artillery, against the
gers' third parallel, shall pass four feet above the
of the glacis,—they make the command of the
of the place over the ravelin, or, if it be re-
hed, over its redoubt three feet, and on these
combined with certain experimental facts, they
nine the dimensions of the general profile,

vertical elevation of a parapet above the terre-plein in its rear, that it may effectually cover the defenders of the work, is usually seven feet six inches —in no case should it be less than six feet. The base of its interior slope should not exceed one-third of its height, and its superior slope should be directed to the edge of the opposite counterscarp; or, if the breadth of the ditch will not admit of this direction, to the foot of the banquette of the covered way. Experience has shewn that in a compact soil the thickness of the parapet should not be less than eighteen feet, to resist the beseigers' batteries, established on the crest of the glacis,—that in light and sandy soil this thickness must be proportionably increased, and that its exterior slope should coincide with the hypothenuse of a right-angled triangle, varying in the length of its base, according to the tenacity of the earth. The breast height, or height of the parapet, above the tread of the banquette, should not exceed four feet, four inches; the breadth of the tread itself should be between four and five feet; and the base of its slope should be at least equal to twice its height, that the ascent and descent may be easy and convenient.

It is on the terre-plein of the work that the guns for the defence are placed in battery. As a general rule, therefore, its breadth must be sufficient not alone for this purpose, but likewise for the free passage, behind them, of the troops and ammunition carriages. The breadtn of the terre-plein, of the main enclosure, measured from the foot of the interior slope of the parapet to the summit of the corresponding slope of the rampart, is usually about thirty-nine feet. If the interior slope of the rampart be not revetted, the horizontal breadth of its base should, to ensure stability, be at least equal to its vertical height; and, in respect to the terre-plein of the ravelin, or of any work which covers another, its breadth should be restricted as much as possible, that on its capture the besiegers may be cramped for space in the construction of their breaching batteries. The terre-plein is not horizontal. It has a gentle fall from front to rear, to carry off the water. About one inch, in every six feet of its breadth, is considered a sufficient inclination for this purpose.

The escarp revetment has an exterior slope of one-fifth of its height, according to Vauban; of one-sixth, according to Cormontaigne. Its relief depends on the depth of the ditch beneath the plane of site, which in no case should be less than sixteen feet, and the command of the opposite glacis. Engineers, in general, to determine the requisite thickness of the revetment, assume that the pressure of the earth, contained between the back of the wall and an inclined plane, passing through the foot of its interior face, at an angle of forty-five degrees with the horizon, has a tendency either to overturn it on the foot of its exterior face, as on a fulcrum or pivot, or to cause it to slide bodily forward at its foundations. In the first case the weight of the pier is supposed to act in a verticle line passing through its centre of gravity, at the extremity of a lever represented by the horizontal distance between this line of direction and the supposed fulcrum or pivot. If, therefore, the weight of the wall—expressed by the area of its vertical section—be multiplied into the length of the said lever, the product will, in this case, represent the stability of the revetment. In the other case the friction of the revetment—expressed by one-fourth of its weight—is equal to its stability. The earth pressing against the revetment is supposed to act at its centre of gravity in a direction parallel to the containing plane. Its horizontal pressure, found by the resolution of forces, is, in this case, equal to its weight, and is supposed to act at the extremity of a lever represented by the vertical distance between its centre of gravity and the foot *of the revetment*. Hence, the area of the vertical section of earth to be supported, multiplied into the length of the said lever, expresses its tendency to overturn the wall; but its tendency to push the wall forward horizontally is only equal to its weight or horizontal pressure. Consequently, equations being formed between the pressures of the earth and the stability of the wall, the result will give the unknown quantity, or the required mean thickness of the revetment.

General Pasley contests the justness of the above principles. He proposes to interpose a second plane, parallel to the former, passing through the foot of the exterior face of the wall, and that the earth above this second plane should alone be considered as tending to overturn the revetment, while the remaining portion included between the two planes, is regarded as tending to cause it to slide off at its foundations. And, on these postulata, he concludes, that for a full escarp revetment, without a berm, or for a demi-revetment, with a berm equal in breadth to one-fourth of the height of the masonry, the mean thickness of the wall should be seventeen-sixtieths of its height,—that for a demi-revetment, without a berm, it should be equal to three-tenths of its height,—and that the length of the counterforts, for each of these revetments, should be equal to one-fifth of their heights respectively. He also concludes, that for a counterscarp revetment, having to retain only a simple terreplein, the mean thickness of the wall should be one-fourth, and the length of each counterfort one-sixth of its height. In all these cases General Pasley supposes the revetment to be countersloped, the counterforts to be rectangular, and the intervals between them to be equal to four times their respective breadths, measured from centre to centre. He further recommends that the foundations of the walls should be deeper in rear than in front; that the courses of the masonry should not be horizontal, except at the external joints, but inclined to the rear, at an angle of about ten degrees, and that the interior face of the wall should be irregular, or formed into steps, that the pressure of the supported earth, acting perpendicularly on the horizontal portions, may add to its stability.

Revetments, serving as retaining walls for wharfs and docks, are usually constructed in the form of portions of hollow cylinders, concave towards the water. According to present practice the exterior face of the wall is an arc subtending an angle of twenty degrees, thirty minutes; and the centre of curvature is in a horizontal plane, passing through its highest point. If, therefore, the vertical height *(H)* of a proposed dock or wharf revetment be given, the required radius of curvature *(R)* will be found by the proportion,—

As, sin. 20½ : Rad. : : *H.* : *R.*—

The back of the wall and the tails of the counterforts are usually, though not necessarily, concentric vith the curve of its exterior face, and the joints of he masonry coincide, or nearly so, with the radii f curvature. The floors of locks and dock basins ould also be in the form of portions of cylinders, nilar to those of the side revetments, that the hy- statical pressure, arising from any water which y have insinuated itself behind the wall or under floor, may not, when the lock or dock is empty, w up the masonry.

f the ditch be wet, and the depth of water be at all s at least six feet, it cannot be too broad,—if dry nnot be too deep, provided that in either case the obtained from the excavation shall not exceed uantity absolutely required for the construction of those portions of the works which are raised above the plane of site. In the first case, if the garrison be but ordinarily vigilant, a surprize is impossible, and the labour and danger of the passage will be proportionally increased,—in the second, not only will the besieger be compelled to descend into the covered-way to establish his breaching batteries, but even in that situation it will be next to impossible for him to open a breach sufficiently near the foot of the revetment to ensure its practicability. The increased depth of the ditch also seriously impedes the besieger in the construction of the descents.

It is obvious that the height of the parapet of the covered-way must in no case be less than six feet above its terre-plein, and that its superior slope should intersect the plane of site at a greater or less distance from its crest in proportion to the proposed declivity or slope of the glacis. The terre-plein of the covered-way is usually about eleven yards broad, measured from the foot of the interior slope of the glacis to the reverse or edge of the counterscarp. Opinions are however divided in respect to this subject. It is contended that if the besieger can, on reaching the crest of the glacis, see the opposite escarp revetment sufficiently near its foot, to breach it the breadth of the terre-plein should be increased; and, on the other hand, if from the depth of the ditch, or from any other cause, the revetment cannot be seen sufficiently near its foot from that situation, that it should be diminished, that the besieger may in either case be compelled to descend into the covered-way before he can commence the construction of his breaching batteries; and in the case last mentioned be further necessitated to cut into the glacis,—a tedious and hazardous operation, especially if its interior slope be sustained, as is sometimes *the case*, by a solid wall of masonry.

Besides the works enumerated and described in the preceding pages, others are occasionally constructed, either to equilibrate the defensive properties of the several fronts, or to occupy ground which, being in the immediate vicinity of the fortified polygon, might, if in an enemy's possession, exercise a dangerous influence on its defence. The additional works employed for these purposes are, Retrenchments, Lunettes, Counterguards, and Crown, and Horn-works.

Cormontaigne contrived a retrenchment for the bastion in the form of a lunette, or cavalier, with a narrow ditch in its front. He traced its faces and flanks parallel to those of the bastion itself, and cut off the communication along the terre-plein, by coupures raised across it on the prolongations of the faces of the adjacent ravelins. He preferred, however, to retrench the bastion, if it were sufficiently capacious, by a fortified front, traced on a line, parallel to, and sufficiently in rear of, its gorge, to embrace the passages between its flanks and the extremities of the collateral tenails. Bastions may also be retrenched by a ditch, and parapet en tenail. In this case, as in the case of the coupures across the terre-plein, the retrenchment must join the faces of the bastion, at their intersections with the prolongations of the collateral ravelins.

If lunettes be employed, those constructed on the saliants of the ravelins should be carried as far as possible into the country, by which means the enemy will be compelled to commence his approaches at the greatest possible distance from the place, and will, of course, be thereby proportionably retarded in his subsequent operations. The lunettes constructed on the saliants of the bastions should, on the contrary, be as little advanced as possible, in order that they may not only flank those on the ravelins, but be themselves exposed to a reverse fire from their flanks, should they be attacked by the enemy, before those works are in his possession.

Counterguards have occasionally been constructed before bastions and ravelins, to cover a defective revetment and to increase their defence. If employed for these purposes their terre-pleins should be made as narrow as possible, and those constructed on the ravelins should be the more saliant, or the furthest advanced into the country.

Horn and Crown-works have been frequently constructed either to strengthen a weak front, or to occupy ground which, in the enemy's possession, would facilitate his operations against the place. The defence which these works afford, however, is not equivalent to the expense attendant on their construction; moreover, they produce this inconvenience,—the besieger is enabled, by means of batteries established on their saliants, to breach the faces of the bastions and ravelins before which they are constructed. It has been proposed, in order to remedy this defect, that they should be constructed beyond the glacis of the place, and that their covered-ways should be joined to the covered-way of the place, in such a manner as to prevent their being attacked by the gorge.

Field Fortification.

Field fortification is based on precisely the same principles as permanent, regard being had to its intent and object, and to the nature and character of the constructions by which those principles are put into operation.

The habitual attitude of an army in the field is defensive. Hence, whatever may be the natural advantages of its position, they should be artificially enlarged. If, for example, its flanks rest on rivers, or are *supported* by woods or forests, the fords, bridges, and utlets should be destroyed, or secured. If it should e commanded by a height, within the range of artilery, or if there should be a village or farm-house on ts flank, in its front, or even in its rear, the height, illage, or house should be intrenched and occupied; and, finally, communications should be opened, esecially to the rear, and batteries should be prepared or their protection.

Defensive field fortification may therefore be defined, the art of reducing, in number, the assailable points of a given post, or position, in such a manner s to establish, in favour of the assailed, on the remaining points, if not a superiority, at least an quality, of active forces.

Various are the works and constructions employed in the field to protect the troops and to enlarge the defensive properties of a post, or position. Among the principal may be classed, Redans, Lunettes, Redoubts, Star, and Bastioned-Forts, Têtes-de-Pont, and Lines, continued, and with intervals, composed of all these works, except the last, infinitely varied and combined.

Redans consist each of two branches or faces, usually about one hundred and fifty feet long, forming a saliant angle of not less than sixty degrees. They are easily constructed, and are of frequent use in the field, especially if an obstinate defence be not intended. Very weak indeed is that which a redan can afford, particularly if it be isolated, or if its rear be undefended. Redans are employed to cover barriers, bridges, fords, and the advanced posts of an army, and to defend the avenues and approaches of farm-houses and villages. Double redans are also occasionally employed for the like purposes.

Lunettes are *redans*, with flanks, and are of superior internal capacity. They are usually employed in front of other works, to cover the approaches, and to search into and defend those parts of the ground which cannot be seen from the work itself. Lunettes are also sometimes constructed in front of the long curtains of continued lines, to cover the outlets and to procure a cross fire on the capitals of the redans and bastions.

Redoubts are enclosed works without flanks, and are either square, polygonal, or circular. Circular redoubts are seldom, if ever, constructed. The defence afforded by a redoubt, especially if its ditch be defended by tambours, or covered loop-holed caponières, is very respectable. Its saliants should—as indeed should the saliants of all works which are not flanked—be directed towards, or be covered by inaccessible objects, either natural or artificial. It has also been recommended as a means of still further improving the defence of these works in the direction of their capitals, to indent the interior slope of the parapet adjoining the saliant, or to form it en cremaillère, —an operation next to impracticable in the field.

Star-Forts consist of a succession of saliant and re-entering angles formed on the sides of a polygon. The defence which a star-fort affords is, particularly if it be formed on a hexagon, or any higher polygon, superior to that afforded by a redoubt. Its saliant angles should not be less than sixty degrees, neither should its re-entering angles be less than nor much exceed ninety degrees. The length of each face should not be less than forty-five feet, that its fire may be respectable, and that its defenders may see into the ditch of the one opposite. Neither should it much exceed ninety feet, that the magnitude of the whole work may be proportioned to, and not exceed, the space absolutely required for the accommodation of a garrison sufficient to line its parapet with, if necessary, a reserve. Star-forts, formed by describing equilateral triangles on the sides of a regular octagon, are, of all others, the most conveniently constructed on the ground, and they afford a sufficiently good defence. But a star-fort, formed by a similar process on the sides of a dodecagon, is the most perfect of all. Its re-entering or flanking angles—the saliant being sixty—are each precisely ninety degrees.

Bastioned-Forts are employed only for the protection of posts of importance. They are traced on the same principles as Vauban's First System,—the length of the lines of defence being determined by the range of an ordinary musquet. On this principle the extent of each front should not be less than one hundred, neither should it much exceed two hundred and twenty yards; and, that the fire of the flanks may search into and defend the ditch in front of the curtain, it should within these limits, be increased, or diminished, in proportion to the height or relief of the proposed parapet. The counterscarp is usually drawn parallel to the curtain, flanks, and faces of the bastions,—the ground in front of, and extending from, the intersection of the lines of defence to the shoulder of the bastion, being formed into a ramp or inclined plane.

Têtes-de-Pont are thrown up on the banks of rivers, to protect the bridges, and to cover and support the passage. The extent and strength of a tête-de-pont must depend on the importance of the communication which it is intended to protect. If the breadth of the river be such that the branches of the work can be flanked from the opposite bank, a simple redan may be employed as a tête-de-pont. Double redans and portions of star and bastioned-forts are also employed as têtes-de-pont, The best position for a work of this description is in the concave bend of the stream,—because, in that situation, not only do its flanks conceal the bridge from the enemy's view, but the ground, over which he must move to the attack, may be defended, at the same time, if the breadth of the stream be not too great, by a cross and a converging fire.

Lines, composed of a succession of redans, connected by straight curtains, not liable to be enfiladed, are, of the various descriptions of connected lines, those best adapted to a level or champaign country. The redans in this kind of lines, that the fire of their faces may reciprocally defend each others saliants, should not be farther apart than one hundred and twenty yards. Lines, composed of redans and straight curtains, are however obnoxious to this objection,—the ditch in front of the curtain is unseen and undefended. If, to remedy this defect, the curtain be broken, as is sometimes the case, into a saliant angle, its faces, unless their prolongations fall within the saliants of the redans, are subject to be enfiladed.

Indented Lines, or Lines en Cremaillère, are liable to be enfiladed in every direction, unless the prolongations of their faces are made to fall on inaccessible objects. Lines en Cremaillère are usually employed on the banks of rivers, or on ground which is more elevated than, or which commands, that occupied by the enemy. The defence of these lines is sometimes strengthened by means of double redans, and flat bastions constructed at intervals, along their front.

Bastioned-Lines afford a powerful defence, especially when they are traced on a concave curve. They are constructed on the principles laid down by Vauban in his First System,—the distances between the collateral bastions being restricted to one hundred and sixty yards, except the curtains be covered by redans, or lunettes. In such cases the intervals between the *bastions* may be extended to two hundred, or even to two hundred and fifty yards, without inconvenience. If the curtains be covered by redans, or lunettes, the faces of these works should be directed to the shoulders, and their saliants, that they may be defended, should be under the fire of the men stationed on the banquettes, of the bastions. The curtains connecting the bastions are occasionally broken into re-entering angles, to increase the defence at the gorges of the redans and lunettes.

Broken Lines, or Lines composed of redans, lunettes, redoubts, and other detached or isolated works, placed at certain distances apart, in one or two ranks—those in the second rank being opposite the intervals of those in the first,—are generally preferred to connected or continued lines. They are more readily adapted to the ground than are continued lines and they admit of greater freedom of action on the part of the defenders, who can pass at once through the intervals, from the defensive to the offensive. Broken lines, or lines with intervals, are less extensive than continued lines, and consequently can, at the same cost of time and labour, be more solidly constructed. Lines of redoubts, or of other enclosed works, if of a respectable profile, possess also this further advantage;—they may, in case of need, be garrisoned by that portion of an army which is comparatively inexperienced. Lines with intervals are traced so that the works each present a saliant angle towards the enemy, while the faces of those in the first line, if produced to the rear, fall upon the faces of those in the second, at an angle of not less than ninety degrees. If this precaution in laying down the tracé be neglected, the works in the front line, if open at their gorges, will be of comparatively little value; but, being flanked, and their saliants defended by the faces of those in the second, they add greatly to the *general* defence.

Every field-work has for its object, to present to an assailant an obstacle to be overcome; and, at the same time, to the assailed a sufficient cover, under the protection of which he can use his arms to the greatest possible advantage. It is therefore indispensable, that its profile should be planned in accordance with these two conditions.

Earth, newly disturbed, exceeds, by about one-sixth, its original bulk, or magnitude. The most effective obstacle that can be presented to an assailant is a ditch of greater or less breadth and depth. It is also, perhaps, the easiest to execute with despatch. On level ground the depth of a ditch should not be less than six feet, neither should it exceed ten, if it is to be excavated by means of the spade and pickaxe alone,—usually the only implements that can be procured in the field. If a ditch be flanked, it should be broad and shallow; if undefended, narrow and deep. The breadth in the one case, or the depth in the other, being determined, the remaining dimension must be such that the excavated earth shall just suffice for the construction of the parapet, and the other elevated portions of the profile. As respects the slopes, their relative steepness must depend on the nature and tenacity of the soil. In earth of little tenacity, an escarp, loaded with the weight of a parapet, cannot sustain itself, if the base of its slope be not equal to its vertical height. The counterscarp has no parapet, or other superincumbent weight, to support. It is, moreover, but little exposed to the fire of an enemy's artillery. Consequently there is no danger, but on the contrary, great advantage, in making it as steep as possible.

The parapet must be of sufficient height and thickness to cover the assailed, and to arrest the flight of the assailant's projectiles. Its height must therefore depend *on the* nature and character of the ground in its front.

If the ground rises as it recedes from a work, the parapet must be high; if it falls, it must be low, in the same proportion. On level ground, the height of the parapet, above its terre-plein, is usually about seven feet, six inches. As regards its thickness, experience has shewn that a twelve pound shot, fired at a range of five hundred yards, will penetrate into a bank of ordinary earth, well rammed, about seven feet; and that a musquet ball, fired from a distance of one hundred and seventy yards, will penetrate into the same bank about eighteen inches. Hence, the mean thickness of a parapet, to resist musquetry, the nature and density of the soil being considered, should not be less than three feet; nor less than twelve feet, to resist artillery. The breadth of its slopes must depend on the breadth of the ditch, and the nature and tenacity of the soil. If the soil be tenacious, the base of the exterior slope need not exceed one-half, or two-thirds, of its height. In common earth the base is usually made equal to its height, and in sand it is sometimes made equal to three times its height. The superior slope should be directed to the summit of the counterscarp, or to the crest of the glacis; or if the ditch should be too narrow to admit of this direction, to a point not more than three feet above it, and the base of the interior slope should not exceed one-third of its height. It should be made as steep as possible, and it is, therefore frequently revetted.

It is usual, in the field, to allow only four feet, two inches, to the breast height, or height of the crest of the parapet, above the tread of the banquette. Hence, the banquette varies in height with the height of the parapet. The breadth of its tread must depend on the order in which the troops are to be formed for the defence. If they are to be formed in a single rank, three feet will be sufficient; if in a double rank, from four to five feet will be required. Artillery, allowing for the recoil, requires from twelve to eighteen feet, according to the nature of the ordnance. In open works, the base of its slope should be at least equal to twice its vertical height. It is sometimes, in enclosed works, cut into steps, to increase their interior capacity.

The berm, if one be constructed, is usually from two to three feet wide. Its precise breadth must depend, however, on the height of the parapet and the nature of the soil. In marshy ground it has been found necessary to place the parapet at from fifty to one hundred feet, in rear of the ditch, that it might not press with such force on the escarp as to cause it to give way. A berm is a great, though at times a necessary, evil. It facilitates an assault or escalade, and, when it is not flanked, it affords to an assailant a convenient resting place. A berm should, therefore, never be constructed, if it can, by possibility, be avoided. If it cannot be avoided, it should be made as narrow as possible, and should not be left horizontal but be sloped, or rounded off, into the ditch.

It is not usual to construct a glacis before a work of moderate elevation. If the command of the parapet be considerable, the construction of a glacis becomes not only advisable, but in many cases indispensable. It allows a less inclination to be given to the superior slope of the parapet, covers its exterior slope, and renders the decent into the ditch more difficult. The profile of the glacis is determined by that of the parapet: its height being less, by at least the height of the latter work, above the tread of the banquette; or, if there be no banquette, by its height above the terre-plein. Its breadth depends, in a great measure, on the configuration of the ground, in advance of the counterscarp, and its slope usually coincides, or nearly *so, with* the superior slope of the parapet, or, rather, *with its* prolongation.

Besides the works described in the preceding paragraphs, there are others, such as Inundations, Abattis, Palisades, Fraises, Trous-de-Loup, Chevaux-de-Frize, and Crows' Feet, which, though usually considered to be auxiliary to them, are also frequently employed independently.

Inundations are formed by means of dams, or dykes, constructed across rivers and water courses. They are formidable obstacles to the approach of an enemy. The extent of an inundation must depend on the extent of the dyke, or dam, by which the water is retained, and the nature and character of the ground in the immediate vicinity of the stream. It should, if possible, be of sufficient depth not to be fordable. If, therefore, either from the nature and character of the ground, or from a deficiency of water, it should be impossible to give an inundation sufficient depth by means of the dam or dike alone, trous-de-loup, or trenches, in two lines—those in the second line being opposite the intervals of those in the first—should be cut to receive a portion of the stream. An intrenched position, covered by an inundation one hundred and fifty feet in breadth, and between five and six feet deep, is generally considered to be inattackable.

Abattis are constructed of moderate sized trees, and
f the limbs and stouter branches of such as are of
rger dimensions. An abattis, well and substantially
nstructed, whether employed independently, or as
auxiliary to another work, is a formidable defensive
stacle. It is, also, in those countries in which wood
ounds, of ready and easy construction. The proper
ition for an abattis must depend on the nature
character of the work to which it is to be ap-
d. It is sometimes placed on the terre-plein of
covered-way, sometimes against the counterscarp,
at others behind an advanced glacis. It is also

employed as a substantive work along the outskirts of woods and forests, across roads, and occasionally to fill up the intervals between detached works, or in broken lines.

Palisades and Fraises are likewise formed out of trees and their branches, cut, according to their dimensions, into triangular prisms, pointed at one extremity. The best position for a line of palisades is in the ditch, at the foot of the counterscarp. Fraises are usually planted horizontally, or slightly inclined to the horizon, on the berm, or crest of the escarp. It is an established maxim, that neither abattis, palisades, nor fraises should be planted in situations which are exposed to the fire of an enemy's artillery.

Trous-de-loup are excavations or pits in the shape of inverted truncated cones, or pyramids. The pits are sunk either in connexion with each other, or at short distances apart, in two or three lines, opposite each other's intervals, and are usually constructed on the edge of the counterscarp, opposite a saliant angle. Each pit should have a pointed stake planted in it, and should be at least five feet deep, otherwise an enemy may avail himself of it, as a cover for his skirmishers.

Chevaux-de-Frize are made of both wood and iron. They but very imperfectly supply the place of an abattis, except when they are employed to close a gateway, or barrier.

Crows'-Feet are formed of iron, and present an obstacle to the advance of cavalry. Each foot consists of four points, about six inches long, so arranged that one is always in the air, while the other three are, like the feet of a tripod, on the ground. Stakes, driven firmly into the earth, and cut off diagonally with a *spokeshave,* at about nine inches from its surface, are an excellent substitute for crows'-feet. They are frequently employed as an obstacle to the advance of both infantry and cavalry.

Experience has demonstrated that soldiers, placed under cover, or behind an epaulment, invariably deliver their fire in lines perpendicular to its crest. It has also been proved that each piece of artillery occupies fifteen, and each infantry soldier from two feet six inches, to three feet lineal of the parapet, by which they are covered; and further, that in enclosed works, each man of the garrison requires, for his accommodation, ten, and each gun and its appurtenances, five hundred superficial feet, independent of the banquette.

It is manifest, therefore, that an intrenchment, traced on a straight, or right line, presents but an indifferent obstacle to an enterprizing enemy, and that serrated lines, or lines which reciprocally flank and defend each other, alone afford an efficient defence; that the saliant angles of a work should be covered by impassable obstacles, and, if its faces be exposed to be enfiladed from a height in its front, or on its flank, that their prolongations should be directed within the commanding points; that lines across valleys should be traced on curves concave towards the enemy; and that an enclosed work, especially if it be isolated, for a garrison of less than eighty-five men, should never be constructed.

Engineers have also established, as fundamental maxims, that a re-entering or flanking angle, should never be less than ninety, nor much exceed one hundred degrees, and that a saliant angle of less magnitude than sixty degrees should, if possible, be avoided; that the configuration of the ground on which a work is to be raised, must determine its figure; that a line which defends, or flanks another, should not be more distant from the flanked or defended line, if it be defended or flanked by musquetry, than one hundred and eighty, nor more than five hundred yards, if defended by artillery; that, if possible, a larger front should be presented to the enemy than he can present in advancing to the attack; that a work thrown up for the defence of a defile, should always be within musquet shot of its debouché; that an enclosed work provided its periphery be not too extensive for its garrison, should embrace the largest possible surface; that the outlets should be placed in those situations which are least exposed to the enemy's fire; that in works raised in the immediate presence of an enemy, the banquette should be formed first, and the exterior slope of the parapet last; that the parapets of field-works should invariably be crowned with loop-holes; that in entrenching a field of battle nothing is to be done that interferes with, or that does not admit of, an instantaneous defence; and that, before a work is commenced, it should be ascertained whether the allotted time, and the means and materials provided, are sufficient for its completion.

The quantity of materials, the number of men, and the time required, for the construction of any description of field-work, must depend on, and be proportioned to, its extent and character, the nature of the soil, the quantity of labour, the means of execution, and the mode of operation.

As regards the materials, the character and extent of the work being known, the requisite quantity may be readily ascertained by a simple arithmetical operation. *If, for* example, it be required to find the number of fascines, sods, or sand-bags, that will be required to revet a slope, or line the cheeks of an embrazure, divide the length of the proposed slope, or cheek, by the length, and its height by the thickness, or diameter of a fascine, sod, or sand-bag, and the product of these two quotients will be the number of fascines, sods, or sand-bags that will be required to revet, or line that particular slope, or embrazure.

The calculatión is not quite so simple as respects the requisite number of men. It depends not alone on the extént and character of the work, but on the relative dimensions of its profile, especially on thóse of the ditch, and on the number of hands that can be employed simultaneously. If the ditch, for example, be of sufficient breadth, the men charged with its excavation may be posted in two ranks, or in one, at intervals of two paces, or four feet between the files. In the first case, the excavated earth will be thrown by the men posted along the outside edge of the ditch tó those on the innér edge, and by these last to a third rank posted on the parapet, by whom it will be spread, and the elevation raised, in accordance with the predetermined profile. If thére should be a berm of more than ordinary breadth, a fóurth rank must be stationed upon it to throw the earth, which in this case will be thrown to them, to the rank on the parapet. It is therefore manifest, that to raise an intrenchment having a bérm one man will be required for every foot in the mean length of its ditch; and that, in the case of a profile without a berm,—the men in the ditch being able to throw the earth on the parapet at a single cast,—three-fourths of that number will be sufficient.

As respects the time required, no precise and general rule of calculation can be given. It must depend on the náturé and density of the soil, and the consequent quantíty of labour, both of which are ever varying. Experience has proved, however, that, in a medium soil, or in a soil which can be moved without the aid of a pickaxe, a man, of ordinary aptitude, can excavate two hundred cubic feet of earth in twelve hours; and of the whole content of the ditch, the portion to be excavated by each man is equal to the area of its profile, multiplied into the distance between the men, if formed in a single, or into half that distance, if formed in a double rank. Hence, if the quantity which each man has to excavate be multiplied by twelve, and divided by two hundred, the quotient will be the time that will be required to raise an intrenchment of the given profile and dimensions in that particular description of soil.

FRICTION,—*Mechanics.*

The friction produced by one body moving over another while they are pressed together, is caused by the change of figure, which, in consequence of the pressure, the contiguous surfaces of the bodies undergo while in motion. By which, a certain force is required to raise the moving surface over the protuberances of the one at rest.

The following are a few useful results obtained from the experiments of M. Coulomb; one body being made to move horizontally on another, and the bodies being pressed together by a certain weight.

When the motion is in the direction of the fibres, the surfaces remaining in contact two or three minutes, and having no unguents between them.

The friction of Oak against Oak is equal to $\frac{1}{2\cdot34}$ of the pressure arising from the weight of the upper body.

Of Oak against Fir	$\frac{1}{1\cdot5}$
Of Fir against Fir	$\frac{1}{1\cdot78}$
Of Elm against Elm	$\frac{1}{2\cdot18}$

In this case the friction does not appear to depend on the velocity, but it increases with the time of contact, reaching its maximum in eight or ten seconds.

If the direction of the motion be perpendicular to that of the fibres, the friction of Oak against Oak, is equal to $\frac{1}{3.76}$ of the pressure.

When Oak rubs against Oak, in the direction of the fibres, and with the surfaces greased.

With a pressure equal to,—

3250 lbs. the friction is equal to $\frac{1}{27.6}$ of the pressure.
850 „ .... $\frac{1}{28.7}$ „ „
250 „ .... $\frac{1}{18.5}$ „ „
50 „ .... $\frac{1}{7.7}$ „ „

Here the friction increases with the time of contact; for example, when the pressure is 3250 lbs., the friction, immediately on application, is $\frac{1}{27.6}$ of the pressure.

In one minute .... $\frac{1}{7.87}$
In one hour .... $\frac{1}{3.7}$
In five days .... $\frac{1}{3.2}$

When the rubbing surfaces are without unguents.

The friction of Iron upon Iron, is $\frac{1}{3.5}$ of the pressure.
Of Iron upon Brass, is $\frac{1}{4.5}$

The friction in this case is independent both of the area of the surface in contact, and of the velocity.

When the surfaces are greased, and the pressure is equal to 1650 lbs.

The friction of Iron on Brass is from $\frac{1}{11.0}$ to $\frac{1}{9.8}$ of the pressure, and depends but little on the time of contact.

Of Iron on Iron $\frac{1}{10.8}$
Of Iron on Oak $\frac{1}{18.2}$ in half a second.
$\frac{1}{5.25}$ in four hours.
$\frac{1}{4.85}$ in four days.

P

Fuze.—*Artillery,—Composition.*

General Table of the Dimensions, etc. of Fuzes.

DIMENSIONS, ETC.	Fuzes.					
	13-Inch.	10-Inch.	8-Inch.	5½-Inch	4⅖-Inch,	Grenade.
Implements.						
Drifts,—						
Diameter of the Body. Inches	·500	·438	·375	·275	·250	·200
Length „ „ No. 1 „	9·600	8·200	7·150	4·875	4·000	2·450
„ „ „ 2 „	4·899	4·125	3·150	2·850	2·200	2·450
Diameter of the Handle „	·900	·750	·700	·550	·460	·425
Length „ „ „	1·700	1·600	1·500	1·370	·950	1·125
Mallets,—						
Weight or Nature.. lbs.	2·063	1·621	1·281	·875	·687	·531
Ladles,—						
Charge or Content, drs.	2·000	1·000	·500	·375	·250	·187
Cases. (Empty.)						
Cup,—						
Depth .... Inches	·750	·700	·550	·400	·400	·300
Diameter, Interior „	1·400	1·200	1·000	·700	·600	·500
Exterior „	2·494	2·137	1·178	1·306	1·187	·900
Body,—						
Length........... Inches	10·237	8·775	7·687	5·362	4·375	2·050
Diameter, Greatest „	2·100	1·800	1·300	1·100	1·000	·800
Least... „	1·575	1·350	1·250	·825	·750	·600
Bore,—						
Depth .... Inches	8·325	7·125	6·295	4·325	3·425	2·165
Diameter .... „	·525	·450	·375	·275	·250	·200
Quick Match, etc.						
Length .... Inches	17·000	14·000	12·000	10·000	8·000	3·000
Number of Threads	6	6	5	3	3	2
Blows to a Charge	21	18	15	13	12	10
Time each Fuze burns, Seconds	35	33	29	18	15	
No. driven by 1 man in a day „	25	25	30	50	70	100

In driving the fuzes it is essential that the several ingredients be thoroughly incorporated, — that the composition be perfectly free from moisture,—that the case be uniformly charged each time the drift is inserted,—and, that the strokes of the mallet be delivered with a steady hand and uniform force—giving always the same number to each ladleful or charge of the composition.

If these particulars be not carefully attended to, the fuze cannot be expected to burn equably, a point on which the effect of the shell principally depends.

The implements required, are:—

Blocks and Sockets	1	Copper Ladles	1
Mallets	1	Guages	1
Drifts	2	Composition Boxes	1
Cutting Knives	1		

Given the Range to find the Length of Fuze.

The 13 and 10-Inch Fuzes each burn ·22, and the 8, 5½, and 4⅖-Inch, ·24 of an inch in a second. If either of these fractions therefore be multiplied by the time of flight, in seconds, the product will be, the corresponding length of fuze, in inches.

Required the length of fuze for a 5½-inch shell, the range being 800 yards, and the time of flight 12¾ seconds?

Here, 12·75 × ·24 = 3·06 Inches.

Note.—If the fuze be driven with the second composition, the above rule must be varied, as 2¼ inches of all the natures burn exactly one minute. This last composition was originally proposed by the late Major Ralph Willet Adye, in a letter from Gibraltar, addressed to the author's father. Major Adye also proposed in that letter, that there should be only two natures of fuzes in the service, the 10- and 5½-inch.

Materials required to complete 1000 Fuzes of each of the undermentioned natures.

MATERIALS.		FUZES.					
		13-Inch.	10-Inch.	8-Inch.	5½-Inch.	4⅖-Inch.	Grenade.
Beech Clefts		200	170	84	40	30	20
Tallow	lbs.	1·000	1·000	·750	·500	·500	·500
Saltpetre	,,	58·500	46·313	27·625	8·750	3·000	1·375
Sulphur	,,	18·000	14·250	8·500	3·375	1·000	·438
Gunpowder	,,	78·000	58·250	35·500	14·088	5·500	2·750
Quick-Match	,,	5·250	4·500	4·000	1·500	1·250	·750
Packer's Twine	,,	·625	·469	·438	·406	·344	·250
Litharge	,,	·063	·063	·063	·031	·031	..
Paint, Lampblack	,,	·563	·500	·375	·219	·219	..
Redlead	,,	·500	·438	·375	·250	·250	..
Whitelead	,,	10·000	9·000	6·000	4·000	4·000	..
Alcohol	qts.	4·500	4·000	2·250	1·750	1·250	1·000
Spirits of Turpentine	,,	·125	·125	·125	·125	·125	..
Raw Linseed Oil	,,	2·500	2·125	1·500	1·000	1·000	..
Brown Paper	qrs.	..	..	..	..	..	1·500
Russia Duck	yds.	32·500	27·500	17·500	12·500	10·000	..

Gravity.—*Bridge,—Gunnery.*

Gravity denotes the natural tendency, or inclination of all bodies towards the centre of the earth. It is either Absolute, or Specific.

Absolute Gravity denotes the whole force with which a body tends downwards.

Specific Gravity, the relative, or comparative gravity of any body, in respect to that of another body of equal bulk, or magnitude. It further denotes that gravity, or weight which is peculiar to each species or kind of body, and by which it is distinguished from all other species, or kinds.

In this sense a body is said to be specifically heavier than another, when, under an equal bulk or magnitude, its weight is greater than that other,—

and, reciprocally, the latter is said to be specifically lighter than the former.

SPECIFIC GRAVITIES OF SOLID AND FLUID BODIES.

Acid, Boracic	1,830
Muriatic	1,170
Nitric	1,218
Nitrous	1,550
Sulphuric	1,841
Air (in a mean state)	1·232
Alabaster	1,874
Alder	800
Alum	1,720
Antimony	6,712
Appletree	793
Arsenic	5,763
Ash (the trunk)	845
Basaltes (prismatic)	2,722
Baytree	822
Beech	852
Bismuth (molten)	9,822
Borax	1,714
Boxwood	1,030
Brandy	837
Brass (cast)	8,000
(wire)	8,544
Brick	2,000
Bronze	8,222
Campeachy Wood	913
Cedar, American	561
Indian	1,315
Palestine	612
Wild	596
Chalk, British	2,784
Charcoal	
Cherrytree	715
Citron Wood	726
Clay	2,160
Coal	1,250
Cobalt (cast)	7,811
Cocoa Wood	1,040
Copper (cast)	8,788
(sheet)	8,915
(wire)	8,878
Cork	240
Cypress, Spanish	644
Earth (common)	1,984
Ebony, American	1,331
Indian	1,209
Eldertree	695
Elm	671
Emery	4,000
Ether, Muriatic	874
Sulphuric	739
Filberttree	600
Fir, Male	550
Female	498
Flint	2,570
Freestone	2,452
Glass (common green)	2,600
(crystal)	3,150
Granite, Aberdeen	2,625
Cornish	2,662
Gold (fine)	19,640
(standard)	18,888
Gun-Metal	8,784
Gunpowder (solid)	1,745
(confined)	920
(loose)	868
Gypsum	2,280
Hazel	600
Ice	930
Iron (cast)	7,425
(wrought)	7,645
Ivory	1,825
Jasmin, Spanish	770

Junipertree	556	Poplar	
Larch	540	Porphery	2,
Lead	11,325	Quincetree	
Lemontree	703	Rhodium	11,
Lignum-Vitæ	1,333	Rosin	1,
Lindentree	604	Salt	2,
Mahogany	1,063	Sand	1,
Maple	750	Silver (fine)	11,
Marble	2,700	Silver (standard)	10,
Mastictree	849	Slate	2,
Mercury (32° Fahr.)	13,598	Sodium	
Milk	1,030	Steel	7,
Mulberry, Spanish	897	Stone (lime)	2,
Medlartree	944	(paving)	2,
Nickel (cast)	7,807	(Portland)	2,
Nitre	1,900	(load)	4,
Oak, English	950	Sulphur	1,
African	980	Tar	1,
Adriatic	990	Teak	
Canadian	872	Tin	7,
Oil, Castor	970	Vine	1,
Linseed	940	Vinegar	1,
Olive	915	Walnuttree	
Turpentine	870	Water (common)	1,
Whale	923	(rain)	1,
Olivetree	927	(river)	1,
Orangetree	705	(sea)	1,
Palladium	11,300	Willow	
Peartree	661	Wine, Bordeaux	
Pewter	7,471	Burgundy	
Pine	660	Champagne	
Pitch	1,150	Moselle	
Platina (pure)	23,400	Port	
Plumtree	785	Yew	
Pomegranate	1,354	Zinc	6,

These numbers being the weights of a cubic foot 1728 cubic inches, of each of the bodies, in av dupois ounces, the quantity in any other weight, the weight in any other quantity, may be read found by the following rules:—

1. *Given the Weight of a Body, to find its Magnitude.*

Multiply the weight of the body, in ounces, by 1728, and divide the product by its tabulated specific gravity,—the quotient will be the content, in cubic inches.

Required the number of cubic inches in a closely-shaken mass of gunpowder weighing 1 lb?

$$\text{Here } \frac{16 \times 1728}{920} = 30{\cdot}05 \text{ Cubic Inches.}$$

2. *Given the Magnitude of a Body to find its Weight.*

Multiply the content of the body, in cubic feet, by its specific gravity, and the product will be the weight, in ounces.

Required the weight of a plank of oak, its dimensions being 10 feet in length, by 3 in breadth, and $2\frac{1}{2}$ in depth?

$$\text{Here } \frac{\cdot 75 \times 950}{16} = 4452{\cdot}125 \text{ lbs.}$$

On the Force of Gravity.

The earth being of an oblate spheroidal form, the force of gravity will be greater near the poles than at the equator; and it is measured by the velocity generated in one second of time by a body falling from a state of rest. Let this velocity be expressed by $2\,\mathrm{g}$, where g represents the space a body falls through during one second, then $\mathrm{f} \propto \mathrm{g}$.

But when a body falls by the force of gravity, the spaces descended are proportional to the squares of the generated velocities. Therefore, let a body fall through equal spaces (s), by two different gravitating forces, represented by f and f, or by g and g. Then,—
$\mathrm{g} : (2\mathrm{g})^2 :: s : 4\,s\,\mathrm{g}$; and $\mathrm{g} : (2g)^2 :: s : 4\,s\,g$.

But 4 s g and 4 s *g*, which represent the velocities generated after describing equal spaces, are, evidently, to each other as g to *g*; that is, as the gravitating forces. Therefore, $f \propto v^2$ when the spaces are equal.

Again, the velocity of a pendulous body vibrating by the force of gravity, is equal to that acquired by a body falling through the versed sine of the arc of vibration; and if two pendulums are of equal length, and describe equal arcs, the versed sines are equal, and f is proportional to the square of the velocity of the pendulum. But the number of vibrations performed in equal times is proportional to the velocity; therefore, the force of gravity in different places on the earth's surface is proportional to the square of the number of vibrations performed, by equal pendulums, in equal times.

The increase of the force of gravity from the equator towards the poles, is proportional to the square of the sine of the latitude; and according to Captain Sabine's experiments, the whole increase of the force of gravity at the pole beyond that at the equator is equal to ·20227,—the force at the equator being expressed by unity.

ON THE CENTRE OF GRAVITY.

The centre of gravity of a terrestrial body or system of bodies, is that point through which if a plane be made to pass, and that plane be brought to a vertical position, the sum of the actions of gravity upon all the points or bodies situated on one side of the plane is equal to the sum of the actions of gravity upon all the points on the other side.

As the gravitating principle acts in lines passing through any given point and the earth's centre, and as these lines may be considered parallel to each other without sensible error, within the limits of any system *of bodies* connected together for mechanical purposes, it follows that the centre of gravity of any body, or system of bodies, may be found by the theory of parallel forces.

It will follow from that theory that the centre of gravity of a right line is in the middle of its length; because the sum of the actions of gravity upon all the points on each side of its middle point will be equal to each other.

And for a like reason, the centre of gravity of a circle, of a regular polygon, of a prism, of a cylinder, of a sphere, or of any regular body, is in its centre.

The centre of gravity of a triangle is found by bisecting any two of its sides, and drawing lines from the points of bisection to the opposite angles,—the intersection of these lines will be the centre of gravity required. For, suppose the triangle to be composed of an infinite number of right lines parallel to one of its sides, the centre of gravity of each line being in its middle, that of the whole figure will be somewhere in a line bisecting all those parallel lines, which will be the line drawn from the middle of one side to the opposite angle. For the same reason, the centre of gravity of the whole will be somewhere in a line drawn from the middle of another side to its opposite angle; therefore, it will be in the intersection of two such lines.

The centre of gravity of two bodies is, from the theory of parallel forces, in a line joining the centre of gravity of both bodies, and is at a distance from each, inversely proportional to the masses or weights of the bodies respectively.

Thus, the common centre of gravity of two bodies, A and B, may be found by the following proportion,— The sum of the weights of A and B, is to the weight of A, as the distance of the centres of gravity of A and B, is to the distance of the common centre of gravity of the two bodies from that of B.

The centre of gravity of any irregular figure may be found by dividing it into triangles, finding the centre of gravity of each triangle separately, joining any two of those centres by a right line, and finding the common centre of gravity of those two triangles, by the proportion just mentioned; expressing the weights of the triangles by their areas which are proportional to their weights, then joining this centre of gravity, and that of a third triangle, and finding the common centre of gravity of the three triangles as before, and so continuing till the centre of gravity of the whole figure is found.

The centre of gravity of any plane surface may be found experimentally thus:—place the surface in two different positions on the edge of a prism, and move it about till it is in equilibrio in both positions; then, draw lines upon the surface, coinciding with the edge upon which it rested in equilibrio, and the intersection of those lines will be the centre of gravity required.

In the same way the centre of gravity of a solid body may be found by balancing it in three different positions on the edge of a prism, and imagining vertical planes to pass through the lines on which the body is in equilibrio; for then the centre of gravity of the body will be the point of the common intersection of all the three planes.

GREASE.—*Friction,—Mechanics.*

The composition used to lubricate axle-trees, etc. in the artillery service, is composed of equal parts of tallow and the coarser kinds of sweet oil, which are melted together, and made up into kegs of 28lbs. each.

GRENADE.—*Fuze,—Shells.*

Grenades may be thrown by hand to the distance of 13 fathoms.

GUN.—*Calibre,—Dispart,—Proof,—Vent,—Windage.* ...**Weight, Dimensions, etc., of English and Foreign Guns in English Measures.**

ORDNANCE, ETC.	Calibre.	LENGTH.				Weight.
		Gun.		Bore.		
		Feet.	Calibres.	Feet.	Calibres.	
	In.					Cwt.
BRASS GUNS.						
ENGLISH :—						
12-Pounders ....*Field*	4·623	6.550	17·002	6·213	16·126	18·00
9 ,, ... ,, ...	4·200	6·000	17·143	5·645	16·129	13·50
6-Pounders ....*Field*	3·668	7·000	22·900	6·679	21·906	12·00
.... ,, ...	3·668	5·000	16·358	4·790	15·668	6·00
3-Pounders ... *Field*	2·913	6·000	24·717	5·371	22·125	6·00
....*Colonial*..	2·913	4·000	16·477	3·834	15·791	3.00
....*Mountain*.	2·913	3·000	12·358	2·834	11·671	2.50
1-Pounders ....*Colonial*..	2·019	5·000	29·717	4·999	29·707	2.50
AUSTRIAN :—						
24-Pounders ....*Siege*	5·911			10·394	21·100	56·25
18 ,, ... ,, ...	5·370			9·789	22·057	43·25
12-Pounders ....*Siege*	4·692			8·998	23·013	30·00
....*Field*	4.692			5·609	14·346	15·25
6-Pounders ....*Field*	3·724			4·452	14·346	7·50
3 ,, ... ,, ...	2.955			3·533	14·346	4·50
BAVARIAN :—						
24-Pounders ....*Siege*	5·829					
18 ,, ... ,, ...	5·301					
12-Pounders ....*Siege*	4.655					
....*Field*	4·621					
6-Pounders ....*Field*	3·686					
3 ,, ... ,, ...	2·955					

Weight, Dimensions, etc. of Guns—*continued.*

ORDNANCE, ETC.	Calibre.	LENGTH.				Weight.
		Gun.		Bore.		
	In.	Feet.	Calibres.	Feet.	Calibres.	Cwt.
BRASS GUNS—*continued.*						
BADEN:—						
24-Pounders .... *Siege*	6·009					
16 " .... "	5·262					
12 " .... *Field*	4·716					
6 " .... "	3·715					
DANISH:—						
36-Pounders .... *Garrison* .	6·889					
24 " .... *Siege*	6·016					
18 " .... "	5·467	10·023	22·000			46 50
12-Pounders .... *Siege*	4·775	8·754	22·000			30·50
.... *Field*	4·775	8·754	22·000			21·75
6-Pounders .... *Siege*	3·790	6·948	22·000			11·75
.... *Field*	3·790	6·317	20 000			9·25
.... "	3·790	5·053	16·000			8·00
3-Pounders .... *Field*	3·008	5·515	22·000			5·75
.... "	3·008	5 014	20·000			
.... "	3·008	4·011	16·000			4·00
DUTCH:—						
24-Pounders .... *Siege*	5·973			9·955	20·000	56·00
18 " .... "	5·405			9·684	21·500	44·00
12-Pounders .... *Siege*	4·719			9·438	24·000	32·75
.... *Field*	4·719			5·899	15·000	17·50
6-Pounders .... *Siege*	3·758			8·084	26·000	17·50
.... *Field*	3·758			4·952	16·000	9·25
3-Pounders .... Field	2·960					

Weight, Dimensions, etc, of Guns—*continued.*

ORDNANCE, ETC.	Calibre.	LENGTH.				Weight.
		Gun.		Bore.		
	In.	Feet.	Calibres.	Feet.	Calibres.	Cwt.
BRASS GUNS—*continued.*						
FRENCH :—						
24 Pounders ......*Siege*	6·010	10·608	21·181	10·124	20·214	54·25
16 „ ...... „	5·262	10 192	23·243	9·765	22·268	39·50
12-Pounders ......*Siege*	4·773	9·621	24·188	9·231	23·209	30·75
......*Field*	4·773	6·961	17·500	6·565	16·506	17·25
8-Pounders ......*Field*	4·174	6·089	17·362	5·726	16·461	11·25
6 „ ...... „	3·774	5·454	17·341	5·220	16·599	7·25
4 „ ...... „	3·315	4·796	17·360	4·546	16·456	5·75
HANOVERIAN :—						
12-Pounders ......*Field*	4·623	6 550	17·002	6·213	16·126	18·00
9 „ ...... „	4·200	6·000	17·143	5·645	16·129	13·50
6 „ ...... „	3·668	5·000	16·358	4·790	15·668	6·00
HESSIAN :—						
24-Pounders ......*Siege*	5·870					
18 „ ...... „	5·334					
12 „ ......*Field*	4·777					
6 „ ...... „	3·688					
PRUSSIAN :—						
24-Pounders ......*Siege*	5·869					
12-Pounders ......*Siege*	4·675					
......*Field*	4·675			6·374	16·376	17·50
6-Pounders ......*Field*	3·706			5·089	16·444	9·00
3 „ ...... „	2·945					

Weight, Dimensions, etc. of Guns—*continued.*

ORDNANCE, ETC.	Calibre.	LENGTH.				Weight.
		Gun.		Bore.		
	In.	Feet.	Calibres.	Feet.	Calibres.	Cwt.
BRASS GUNS—*continued.*						
RUSSIAN:—						
24-Pounders .... *Siege*	5·972			9·656	20·041	58·00
18 „ .... „	5·417			9·047	20·041	43·00
12-Pounders .... *Siege* ...	4·740			8·328	21·083	31·25
.... *Field*	4·740			6·221	15·750	15·75
.... „	4·740			4·839	12·250	9·25
6-Pounders .... *Field*	3·762			5·094	16·250	7·00
SAXON:—						
24-Pounders .... *Siege*	5·899					
18 „ .... „	5·656					
12 „ .... *Field*	4·618			6·384	16·588	
8 „ .... „	4·092					
6 „ .... „	3·686			4·230	16·485	
4 „ .... „	3·274					
SPANISH:—						
24-Pounders .... *Siege*	5.906					
16 „ .... „	5.137					
12 „ .... *Field*	4.709					
8 „ .... „	4.108					
4 „ .... „	3·286					
WURTEMBURGH:—						
12-Pounders .... *Field*	4.659			6·016	15·496	14·25
6 „ .... „	3·677			5·103	16·656	8·00

Weight, Dimensions, etc. of Guns—*continued.*

ORDNANCE, ETC.	Calibre.	LENGTH.				Weight.
		Gun.		Bore.		
	In.	Feet.	Calibres.	Feet.	Calibres.	Cwt.
IRON GUNS.						
ENGLISH :—						
10-Inch Guns ....*Naval*	10·000	9·334	11·200	9·167	11·000	84·00
68-Pounders .. ...*Naval*	8·050	9·000	13.416	8·820	13·148	65·00
Garrison	8·050	8·834	13·168	8·650	12·919	60·00
Naval	8·050	8·500	12·671	8·358	12·500	60·00
"	8·050	6·708	10·000	6·708	10·000	50·00
32-Pounders . ....*Naval*	6·410	9·583	17·942	9·217	17·263	64·00
Garrison .	6·410	9·500	17·785	8·934	16·724	56·00
Naval	6·410	8·000	14·977	7·629	14·282	48·00
"	6·350	7·500	14·173	7·216	13·637	40·00
"	6 300	6·500	12·381	6·245	11·895	32·00
"	6·300	6·000	11·429	5·765	10·984	25·00
24-Pounders ......*Garrison* .	5·823	9·500	19 577	8·951	18·446	50·00
Siege	5·823	9·000	18·547	8·454	17·422	47·50
Naval	5·823	7·500	15·456	6·996	14·417	40·00
18-Pounders ......*Garrison* .	5·292	9·000	20·408	8·480	19·227	42·00
Siege	5·292	8·000	18·140	7·479	16·957	37·50
Naval....	5·170	7·000	16·249	6·756	15·681	22·00
"	5·170	6·000	13·926	5·751	13 349	20·00
"	5·170	5·500	12·756	5·305	12·314	15·00
12-Pounders ......*Garrison* .	4·623	9·000	23·361	8·520	22·113	34·00
Siege	4·623	8·500	22·063	7·667	19·948	33 00
Naval	4·623	7·500	19·466	7 020	18·222	29·50
9-Pounders ......*Garrison* .	4·200	8·500	24·285	8·040	22·971	28·50
Naval	4·200	7·500	21·428	7·036	20·013	26·00
"	4·200	7·000	20·000	6·540	18·447	25·00
6-Pounders ......*Garrison* .	3·668	8·500	27·808	8·082	26·433	23·00
Naval	3·668	8·000	26·172	7 579	24·524	22·00
"	3·668	7·500	24·536	7·080	23·162	21·00
"	3·668	7·000	22·900	6·663	21·524	20·00
"	3·668	6·500	21·268	6·080	19·618	18·00
"	3·668	6·000	19·629	5·581	18·258	17·00

Weight, Dimensions, etc. of Guns—*continued.*

ORDNANCE, ETC.	Calibre.	LENGTH.				Weight.
		Gun.		Bore.		
	In.	Feet.	Calibres.	Feet.	Calibres.	Cwt.
IRON GUNS—*continued.*						
AUSTRIAN:—						
18-Pounders .... *Garrison*	5·370			9·309	20·801	45·25
12 " .... "	4·692			8·881	22·714	34·25
6 " .... "	3·723			7·397	23·865	14·00
DANISH:—						
36-Pounders ...... *Naval* ..	6·941	10·412	18·000			87·25
24 " .... "	6·042	10·322	20·500			65·75
18 " .... "	5·491	9·380	20·500			51·50
DUTCH:—						
24-Pounders .... *Naval* ..	5·973			8·882	17·843	55·75
18 " .... "	5·405			8·464	18·791	45·24
12 " .... "	4·719			8·182	20·806	32·25
6 " .... "	3·758			7·151	22·833	17·25
FRENCH:—						
36-Pounders .... *Naval* ..	6·883	9·592	16·723	8·770	15·580	69·00
30 " .... "	6·483	9·281	17·177	8·655	16·019	59·75
24-Pounders .... *Naval* ..	6·001	9·059	18·115	8·485	16·968	49·25
.... "	6·001	8·332	16·660	7·939	15·875	41·75
18-Pounders .... *Naval* ..	5·461	8·526	18·738	7·992	17·561	40·25
12-Pounders .... *Naval* ..	4·773	7·993	20·095	7·525	18·915	29·00
.... "	4·773	7·266	18·272	6·927	17·415	23·00
8-Pounders .... *Naval* ..	4·174	7·283	20·937	6·871	19·776	19·75
6 " .... "	3·789	7·460	23·627	7·089	22·453	16·75

Weight, Dimensions, etc. of Guns—*continued.*

ORDNANCE, ETC.	Calibre.	LENGTH.				Weight.
		Gun.		Bore.		
	In.	Feet.	Calibres.	Feet.	Calibres.	Cwt.
IRON GUNS —*continued.*						
HANOVERIAN:—						
24-Pounders ......*Siege*	5·823	9·000	18·547	8·454	17·422	47·50
18 „ ...... „	5·292	8·000	18·140	7·479	16·957	37·50
12 „ ......*Garrison* .	4·623	9.000	23·361	8·520	22·113	34·00
9 „ ...... „	4·200	8·500	24·285	8·040	22·971	28·50
RUSSIAN:—						
36-Pounders ......*Garrison* .	6·837			10·730	18·833	96·25
30 „ ...... „	6·433			10·105	18·833	81·00
24 „ ...... „	5·972			9·829	19·750	67·75
18 „ ...... „	5·417			8·915	19·750	51·25
12 „ ...... „	4·740			8·179	20·917	32·75
6 „ ...... „	3·762			6·558	20·917	15·75
3 „ ...... „	2·986			3·981	16·000	6·00
SAXON:—						
18-Pounders ......*Garrison* .	5·553					
12 „ ...... „	4·851					
6 „ ...... „	3·850					
SWEDISH:—						
36-Pounders ......*Garrison* .	6·993			9·324	16·000	49·50
24 „ ......*Siege*	6·109			8·145	16·000	39·50
12 „ ...... „	4·850			6·467	16·000	16·75
6 „ ...... „	3·862			5·471	17·000	7·75
......*Field*	3·862			4·332	13·458	4.00

GUNNERY.—*Fluids,—Motion,—Pendulum.*

Mathematicians, treating on Gunnery, or the Science of Military Projectiles, divide the subject into two branches. In the one, they disregard the resistance which the air opposes to the moving body,—in the other, they endeavour to measure, and allow for, the amount of that resistance. They have also endeavoured to determine the form of the trajectory described by a projectile moving through the atmosphere, and the velocity due to it, under all the circumstances of its motion.

ON THE MOTION OF PROJECTILES IN A NON-RESISTING MEDIUM.

When a shot is discharged from a gun, in a non-resisting medium, by the expansive force of gunpowder, it would, by the laws of impulsive force, move for ever in a rectilinear direction with an uniform velocity, if it were not for the action of gravity. But in every case, except that in which the gun is fired in a direction perpendicular to the horizon, the power of gravity continually deflects the shot from the rectilinear direction which the force of the powder alone would cause it to take, and compels it to describe a curve line tending towards the earth, and to which curve the axis of the gun is a tangent. And the place of a shot at any time will be found by compounding the motion in the direction of the tangent during that time, with the motion which would take place by the action of gravity alone in the same time.

Now, the spaces described by the force of the powder alone in the direction of the axis of the gun would be proportional to the times of describing them; but the force of gravity acting always perpendicularly to the horizon, and being accelerative, the deflections of the shot, from the rectilinear direction, may be conceived to take place in parallel lines, making a constant angle with the axis of the gun produced, and the lengths of those lines will be proportional to the squares of the times of describing them, which times, by hypothesis, are equal to the times of describing the spaces on the tangent between the gun and the line of direction of gravity. Therefore, the deflections from the tangent by the action of gravity, are proportional to the squares of the corresponding spaces on the tangent; and this relation of the spaces is a property of the parabola. Therefore, the trajectory of the shot, if its motion were not resisted by the air, would be a parabolic curve.

Consequently, knowing the initial velocity of the shot, and the position of the axis of the gun, the form of its trajectory may be traced, and the extent of its range determined,—for the velocity, multiplied by any given time, will express the space which the shot would describe, by the force of the powder alone, in that time, on the axis of the gun produced. Then, if a vertical line be drawn through the extremity of this space, the deflection produced by gravity may be found by multiplying the square of the given time by $16\frac{1}{12}$ feet, the space a body falls through in one second; and this length being set off from the tangent upon the said vertical line, will give the place of the shot, in the curve, at the given time. The extent of the horizontal range may be determined as follows.

Find the space through which a body must fall to obtain a velocity equal to the initial velocity of the shot, and on a line equal to this, as a diameter, describe a semi-circle. Then, if a line be inscribed in this semi-circle from one extremity of the diameter, and making an angle with it equal to the elevation of the gun, and a perpendicular be let fall upon the diameter from the place where the line intersects the circle, it will be equal to one-fourth of the range.

If the range be bisected by a perpendicular, which also cuts the axis of the gun produced, the middle of this line between the range and the axis will be the vertex of the parabola, or highest point of the trajectory. The space due to the initial velocity is called the impetus.

ON THE RESISTANCE OF THE AIR.

It has been shewn by experiments made at Woolwich, that the resistance of the atmosphere to the motion of shot, is nearly proportional to the squares of the velocities, when the shot are equal in diameter and weight, and when the velocities are less than 300 feet per second; but when the velocities are greater than this, the resistance is in a higher ratio than the squares of the velocities, gradually increasing with them. When the shot are of equal specific gravities, but of unequal diameters, and move with equal velocities the resistance is nearly proportional to the surfaces, or to the squares of the diameters, but in a higher ratio, when the velocities are considerable.

Dr. Hutton found by a series of experiments on the motion of an iron shot of 1·965 inches diameter, and 1·401 lbs. weight, with different initial velocities, of from 300 to 2000 feet per second, that the resistance was nearly proportional to the 2·1 power of the velocity; but this term not being convenient, he assumed the resistance equal to $M.\ v^2 \times N.\ v$; where M and N are indeterminate co-efficients of the velocity (v) the values of which are obtained by making this expression equal to the resistances determined by experiment with two different velocities. From the two equations thence arising, we have $M = \cdot 00002665$, and $N = -\cdot 004025$, whence the resistance of the atmosphere against that ball, expressed in avoirdupoise *pounds*, is $\cdot 00002665\ v^2 - \cdot 004025\ v$.

When the velocity is less than 300 feet per second, the resistance is expressed by $\cdot 00001765\, v^2$.

To adapt these theorems to balls of any other size they must be altered in the ratio of the squares of the diameters of the balls; which reduces the former theorem to $\left\{ \cdot 000007565\, v^2 - \cdot 00175 \right\} d^2$, and the latter to $\cdot 0000044 d^2 v^2$; d being the diameter of the given ball.

When a ball is fired vertically upwards, the weight of the ball is to be added to the terms, expressing the resistance, in order to give the whole resistance to the ball's motion; but the inertia of the ball is a force opposing the action of the air against it, and this inertia is proportional to the weight of the ball. Therefore the retarding force is expressed by $\frac{(M.v^2 - N.v)d^2 + W}{W}$, where $M = \cdot 000007565$, $N = \cdot 00175$, and $W =$ the weight of the ball in pounds. And this being substituted for f, in the fluxional formula for variable motions; viz. $v.\, \dot{v} = 2\, g.f.\, \dot{s}$; there is obtained by integration, the formula $669\, d \times$ com. log. $\frac{v^2 - 231 \cdot 5\, v + 18600\, d}{18600\, d}$, for the space described, or the altitude to which an iron ball, of which d is the diameter, and v the initial velocity, will ascend vertically in the air.

In this fluxional formula, $v =$ the initial velocity, $g = 16\frac{1}{12}$, feet, $f =$ the retarding force, and $s =$ the space ascended.

When a ball descends in the atmosphere from a state of rest, it is evident that the motion begins, and increases by the weight of the ball, which is the constant accelerating force, and would produce an equal increase of velocity in equal times, if it were not for the diminution of motion caused by the air's resistance. But this resistance begins with nothing, and continually increases, in proportion to the square of the velocity of the ball, nearly.

It is evident therefore, that, as the accelerating force is always the same, and the resistance always increasing, it must happen that the latter will, at length, become equal to the former. When this takes place, there can, afterwards, be no further acceleration of the motion, the impelling force and the resistance being equal to each other, and the ball must, ever after, descend with an uniform motion. The velocity which the ball has, when its motion becomes uniform, is called its terminal velocity.

Since the resistance of the air is to be equal to the accelerative force, that is, to the weight of the ball, substitute in the formula of resistance, viz.— $\left\{ \cdot000007565\, v^2 - \cdot00175\, v \right\} d^2$, the value of d, that is, the diameter of the ball, and make the result equal to the weight of the ball, in pounds; then from this equation may be obtained the value of v, which is the terminal velocity required.

As the above formula of resistance is adapted to solid iron balls only, the result must be modified when the balls are of lead, or when shells are used. Shells filled with powder have less weight than iron balls of equal diameters in the proportion of 1 to 1·42; therefore, the power to oppose the air's resistance will be less in the same ratio, and the terminal velocity will be less in the ratio of 1 to $\sqrt{1\cdot42}$, or of 1 to 1·19. Consequently, having found the terminal velocity for a solid iron ball of the same diameter as the shell, by the above rule, divide it by 1·19, and the quotient will be the required terminal velocity of the shell.

ON THE TRAJECTORY OF SHOT IN THE ATMOSPHERE.

The efforts hitherto made to determine, by theory, the range of a shot, and the form of its trajectory in the air, may be said to have entirely failed, except when the velocity of the projectile is small, in which case, the circumstances of its motion do not differ materially from those determined by the parabolic theory. Sir Isaac Newton, who first developed the laws of motion in resisting media, shews that the path of a shot through the air must be of the hyperbolic kind, having the asymptote of the descending branch perpendicular to the horizon; and he considers that the conical hyperbola will represent the path with sufficient accuracy for practice.

From the experimented ranges of two balls of equal bulks and weights, and discharged with equal velocities, at different angles of elevation of the gun, he determines, by a tentative process, the positions of the asymptotes of either; and thence, by the general properties of the hyperbola, he constructs the curves they describe. He, also, shews how the range and curve may be found, when the velocity remains the same, and the elevation is changed, or, when the elevation is the same, and the velocity is changed; and, consequently, the real trajectory may be determined for a shot discharged in any circumstances, provided we have from experiment the ranges of two shot, similar and equal to that of which the trajectory is required, and fired with different velocities from a gun, also similar and equal to that of which is to be used. The practice carried on at Sutton Heath in 1811 and 1812, afford many data for shot and shells, by which the hyperbolic theory has been tried; *and it has been found to give ranges which do not differ more from those obtained by experiment than many of these differ from each other, even when all circumstances are equal;* but more such experiments will be necessary, before the hyperbolic theory can be applied to all the different kinds of shot and guns.

According to Dr. Hutton the angle of elevation for the greatest horizontal ranges is between 30 and 45 degrees, being gradually more below 45 degrees, as the shot is smaller and the velocity greater. The ascending branch of the trajectory is less curved than the other, and the vertex of the curve is nearer to the remote extremity of the range than to the gun, and the point of greatest curvature is beyond the vertex. The ball does not ascend so high as it would if it moved in a parabola, and the horizontal velocity is continually diminishing, both in the ascending and descending branch.

Since Sir Isaac Newton's time, mathematicians have investigated, according to the received law of the resistance of the air, formulæ for determining the ordinates of the trajectory, when the inclination of the gun and the initial and terminal velocities of the shot are given; but they are excessively complicated, and the best formulæ of this kind that have been given produce, for the results, ranges which are often greater, by one-half, than those found by experiment. The following is one of the most simple:—

$$y = \left\{ \tan. E + \frac{H}{2\,h \cos. E} \right\} x - \frac{H}{2\,h} \left\{ e^{\frac{x \cos. E}{H}} - 1 \right\}$$

Where E is the elevation of the gun; $H =$ the height due to the terminal velocity; $h =$ the height due to the initial velocity; $e = 2{\cdot}71828$; $x =$ the abscissa, reckoned from the gun on a horizontal line, and $y =$ the ordinate to the curve, perpendicular to the horizon.

ON THE VELOCITIES OF SHOT.

Experiments made at Woolwich on the velocities of shot, give the following results:—

1. The velocities communicated to shot of the same *weight, by* different charges of powder, are nearly pro-

portional to the square roots of the charges.

2. When the charges are of equal, and the shot of unequal weights, the velocities are inversely proportional to the square roots of the weights nearly.

3. When both the weights and charges are unequal. the velocities are proportional to $\frac{\sqrt{\text{charges}}}{\sqrt{\text{weights}}}$, nearly.

4. When the charges of powder are equal, the velocities increase with the length of the gun, but not in so high a ratio. The same thing may be said of the maximum velocity.

5. The ranges increase in a much lower ratio than the velocities: hence little is gained in the range, by a great increase in the length of the gun. A double length of gun only increases the range about one-seventh.

6. The initial velocities increase with the charge to a certain degree, after which they diminish till the bore is filled with powder.

To find the velocity with which a shot of a given weight will be projected from a gun, with a given charge of powder.

By experiment it has been found, that 8 oz., or ·5 pounds of powder, will discharge a one-pound ball with a velocity of 1600 feet per second; therefore by the third rule, $\sqrt{5} : 1600 :: \frac{\sqrt{\text{charge}}}{\sqrt{\text{weight}}} : 2263$, $\frac{\sqrt{\text{charge}}}{\sqrt{\text{weight}}}$, the velocity required.

To find the velocity with which an iron ball, projected horizontally in the air, moves, after having described a certain given space.

By substituting the expression for the retarding force f; viz. $\frac{m v^2 - n v}{w} d^2$, in the fluxional equation for motion, viz. $v \dot{v} = 2 g f \dot{s}$; there arises, by integration, the equation $S = \frac{32 m d^2}{w} \times \text{hyp. log.} \frac{V-231}{v-231}$; where $S =$ the given space, $m =$ 00000756, $w =$ the weight, and $d =$ the diameter of the ball, $V =$ the given initial velocity, and $v =$ the velocity required.

From this equation, by reduction, we have $\frac{d s^2}{9511 \cdot 5\, w} = \text{com. log.} \frac{V-231}{v-231}$, and to find v, consider the left-hand member of the equation as a logarithm, and find, in a table, the natural number corresponding to it, which call N; then $N = \frac{V-231}{v-231}$, from which v may be found.

This last problem is useful in determining the elevation which should be given to a gun, that, when the shot is discharged with a given velocity, it may strike an object placed at a given distance from it. For which purpose, find, by this problem, the velocity of the shot after it has passed over the given space; and the mean of this, and the initial velocity, may be considered as the medium uniform velocity of the shot within that space; divide the given space, in feet, by the velocity, and it will be the time of flight in seconds; lastly, find the space through which a body will descend vertically in vacuo, during that time, by the power of gravity. If the given space be not considerable, this will give the required deflection of the shot, in feet, from the axis of the gun, when arrived at the object; from which the angle of elevation may be found trigonometrically.

A Table of First Grazes with *Guns*, *Howitzers*, *Mortars*, and *Carronades*.

ORDNANCE, etc. (Iron Guns.)

10-Inch Gun. (84 Cwt.)			68-Pounder. (65 Cwt.)				68-Pounder. (65 Cwt.)			68-Pounder. (60 Cwt.)		
	Graze (Yards.)			*Graze* (Yards.)			*Graze* (Yards.)			*Graze* (Yards.)		
Charge, etc.	Calculated.	Experimental.	Charge, etc.	Calculated.	Experimental.	Elevation. Deg.	Experimental.	Calculated.	Charge, etc.	Experimental.	Calculated.	Charge, etc.
Charge 12lbs. Hollow Shot. Length of Gun 9-ft. 4-in. Windage ·16-in.		350	*Charge 11lbs. Solid Shot. Length of Gun 9-ft. Windage ·125-in.*		370	P B			*Charge Hollow Shot. Length of Gun 9-ft. Windage ·125-in.*	360		*Charge 9 lbs. Solid Shot. Length of Gun 8-ft. 6-in. Windage ·125-in.*
	333			359		¼					330	
	473			510		½					469	
	583			628		¾					577	
	676	660		728	670	1				660	670	
	759			817		1¼					752	
	834			898		1½					827	
	905			974		1¾					898	
	972	950		1045	1080	2				950	963	
	1035			1113		2¼					1026	
	1095			1177		2½					1086	
	1153			1240		2¾					1144	
	1210	1210		1300	1300	3				1200	1200	
	1264			1358		3¼					1254	
	1317			1414		3½					1306	
	1372			1469		3¾					1357	
	1420	1440		1523	1500	4				1430	1407	
	1468			1565		4¼					1456	
	1517			1627		4½					1504	
	1564			1677		4¾					1551	
	1611	1700		1728	1700	5				1620	1598	
	1657			1775		5¼					1643	
	1702			1823		5½					1688	
	1747			1871		5¾					1733	
	1791			1918		6					1777	
	1834			1964		6¼					1820	
	1877			2009		6½					1863	
	1920			2054		6¾					1905	

Table of First Grazes—*continued.*

Ordnance, etc. **(Iron Guns.)**

68-Pounder. (50 Cwt.)			68-Pounder. (50 Cwt.)				32-Pounder. (64 Cwt.)			32-Pounder. (48 Cwt.)		
	Graze (Yards.)			Graze (Yards.)			Graze (Yards.)			Graze (Yards.)		
Charge, etc.	Calculated.	Experimental.	Charge, etc.	Calculated.	Experimental.	Elevation. Deg	Experimental.	Calculated.	Charge, etc.	Experimental.	Calculated.	Charge, etc.
Charge 7lbs. Solid Shot. Length of Gun 6-ft. 8½-in. Windage ·125-in.		320	*Charge. Hollow Shot. Length of Gun 6-ft. 8½-in. Windage ·125-in.*			P.B.	420		*Charge 10 lbs. Solid Shot. Length of Gun 9-ft. 7-in. Windage ·233-in.*	360		*Charge 8 lbs. Solid Shot. Length of Gun 8-ft. Windage ·233-in.*
	301					¼		411			365	
	429					½		584			518	
	527					¾		718			638	
	612	600				1	820	833		730	739	
	687					1¼		933			830	
	757					1½		1026			912	
	821					1¾		1112			989	
	882	870				2	1170	1192		1050	1061	
	940					2¼		1269			1130	
	995					2½		1342			1196	
	1048					2¾		1412			1259	
	1100	1100				3	1480	1480		1320	1320	
	1150					3¼		1545			1378	
	1198					3½		1608			1436	
	1246					3¾		1670			1401	
	1292	1300				4	1730	1731		1540	1546	
	1337					4¼		1789			1599	
	1382					4½		1847			1651	
	1426					4¾		1903			1702	
	1469	1480				5	1950	1959		1740	1752	
	1511					5¼		2013			1802	
	1553					5½		2058			1851	
	1595					5¾		2119			1898	
	1635					6		2171			1946	
	1676					6¼		2223			1988	
	1716					6½		2273			2039	
	1755					6¾		2323			2085	

TABLE OF FIRST GRAZES—*continued.*

ORDNANCE, ETC. (IRON GUNS.)

32-POUNDER. (40 Cwt.)			32-POUNDER. (32 Cwt.)			ELEVATION.	32-POUNDER. (25 Cwt.)			24-POUNDER. (50 Cwt.)		
CHARGE, ETC.	*Graze* (Yards.)		CHARGE, ETC.	*Graze* (Yards.)		Deg.	*Graze* (Yards.)		CHARGE, ETC.	*Graze* (Yards.)		CHARGE, ETC.
	Calculated.	Experimental.		Calculated.	Experimental.		Experimental.	Calculated.		Experimental.	Calculated.	
Charge 6lbs. Solid Shot. Length of Gun 7-ft. 6-in. Windage ·173-in.			*Charge 5lbs. Solid Shot. Length of Gun 6-ft. 6-in. Windage ·122-in.*		360	P B	250		*Charge 4 lbs. Solid Shot. Length of Gun 6-ft. Windage ·122-in.*	400		*Charge 8 lbs. Solid Shot. Length of Gun 9-ft. 6-in. Windage ·211-in.*
	353			339		¼		275			400	
	502			482		½		392			567	
	618			593		¾		482			698	
	716	720		687	700	1	520	560		800	808	
	804			771		1¼		629			907	
	885			849		1½		693			997	
	959			920		1¾		752			1081	
	1020	1020		988	980	2	760	808		1150	1160	
	1095			1052		2¼		862			1234	
	1159			1114		2½		913			1305	
	1220			1173		2¾		962			1374	
	1280	1280		1230	1230	3	1010	1010		1440	1440	
	1337			1285		3¼		1056			1503	
	1392			1338		3½		1101			1565	
	1447			1391		3¾		1145			1625	
	1500	1500		1442	1450	4	1260	1188		1670	1684	
	1551			1495		4¼		1230			1741	
	1602			1541		4½		1272			1798	
	1652			1589		4¾		1313			1853	
	1701	1701		1636	1640	5	1500	1353		1850	1907	
	1749			1683		5¼		1393			1960	
	1796			1729		5½		1432			2013	
	1843			1774		5¾		1470			2064	
	1890			1819		6		1509			2115	
	1935			1863		6¼		1546			2165	
	1980			1907		6½		1584			2215	
	2025			1950		6¾		1621			2264	

Table of First Grazes—*continued.*

Ordnance, etc. **(Iron Guns.)**

24-Pounder. (40 Cwt.)			18-Pounder. (42 Cwt.)				18-Pounder. (22 Cwt.)			18-Pounder. (15 Cwt.)		
	Graze (Yards.)			Graze (Yards.)			Graze (Yards.)			Graze (Yards.)		
Charge, etc.	Calculated.	Experimental	Charge, etc.	Calculated.	Experimental.	Elevation. Deg.	Experimental.	Calculated.	Charge, etc.	Experimental.	Calculated.	Charge, etc.
Charge 8lbs. Solid Shot. Length of Gun 7-ft. 6-in. Windage ·211-in.		380	*Charge 6lbs. Solid Shot. Length of Gun 9-ft. Windage ·193-in.*		400	P. B.	330		*Charge 3lbs. Solid Shot. Length of Gun 7-ft. Windage ·071-in.*	260		*Charge 2lbs. Solid Shot. Length of Gun 5-ft. 6-in. Windage ·071-in.*
	388			382		¼		330			273	
	551			543		½		469			388	
	678			668		¾		577			477	
	785	780		774	780	1	650	670		520	554	
	881			868		1¼		752			623	
	969			955		1½		827			686	
	1050			1035		1¾		898			745	
	1127	1120		1111	1120	2	950	963		770	800	
	1200			1182		2¼		1022			853	
	1269			1251		2½		1086			903	
	1335			1286		2¾		1144			952	
	1400	1400		1380	1380	3	1200	1200		1000	1000	
	1462			1441		3¼		1254			1045	
	1522			1500		3½		1306			1090	
	1581			1558		3¾		1357			1134	
	1638	1620		1615	1600	4		1407		1200	1176	
	1694			1670		4¼		1456			1218	
	1749			1724		4½		1504			1260	
	1803			1778		4¾		1551			1300	
	1856	1800		1830	1780	5		1598			1340	
	1907			1881		5¼		1643			1379	
	1959			1932		5½		1688			1418	
	2009			1981		5¾		1733			1457	
	2059			2030		6		1777			1494	
	2108			2079		6¼		1820			1532	
	2156			2127		6½		1863			1569	
	2204			2174		6¾		1905			1606	

TABLE OF FIRST GRAZES—*continued.*

ORDNANCE, ETC. **(IRON GUNS.)**

12-POUNDER. (34 Cwt.)			12-POUNDER. (29½ Cwt.)				9-POUNDER. (28½ Cwt.)			OUNDER. (23 Cwt.)		
CHARGE, ETC.	*Graze* (Yards.) Calculated.	*Graze* (Yards.) Experimental.	CHARGE, ETC.	*Graze* (Yards.) Calculated.	*Graze* (Yards.) Experimental.	ELEVATION. Deg.	*Graze* (Yards.) Experimental.	*Graze* (Yards.) Calculated.	CHARGE, ETC.	*Graze* (Yards.) Experimental.	*Graze* (Yards.) Calculated.	CHARGE, ETC.
Charge 4lbs. Solid Shot. Length of Gun 9-ft. Windage ·169-in.		400	*Charge 4lbs. Solid Shot. Length of Gun 7-ft. 6-in. Windage ·169-in.*		380	P. B.	370		*Charge 3lbs. Solid Shot. Length of Gun 8-ft. 6-in. Windage ·12-in.*	360		*Charge 2lbs. Solid Shot. Length of Gun 8-ft. 6-in. Windage ·118-in.*
	377			368		¼		359			348	
	535			523		½		509			494	
	658			642		¾		628			608	
	762	770		750	750	1	730	728		700	704	
	859			836		1¼		817			791	
	941			919		1½		898			870	
	1020			997		1¾		974			943	
	1094	1100		1070	1080	2	1050	1045		1020	1012	
	1165			1139		2¼		1113			1078	
	1232			1205		2½		1178			1141	
	1297			1268		2¾		1240			1201	
	1360	1360		1330	1330	3	1300	1300		1260	1260	
	1420			1389		3¼		1358			1316	
	1479			1447		3½		1414			1371	
	1536			1503		3¾		1469			1424	
	1592	1540		1557	1500	4	1460	1523		1400	1477	
	1646			1611		4¼		1575			1528	
	1700			1664		4½		1627			1578	
	1752			1715		4¾		1677			1627	
	1804	1700		1765	1650	5	1600	1727		1520	1675	
	1855			1815		5¼		1775			1723	
	1905			1864		5½		1823			1770	
	1954			1912		5¾		1871			1816	
	2002			1960		6		1918			1861	
	2050			2007		6¼		1964			1906	
	2097			2053		6½		2009			1951	
	2144			2099		6¾		2054			1996	

TABLE OF FIRST GRAZES—*continued.*

ORDNANCE, ETC. (BRASS GUNS.)

12-POUNDER. (18 Cwt.)			9-POUNDER. (13¼ Cwt.)				6-POUNDER. (12 Cwt.)			6-POUNDER. (6 Cwt.)		
	Graze (Yards.)			*Graze* (Yards.)		ELEVATION.	*Graze* (Yards.)			*Graze* (Yards.)		
CHARGE, ETC.	Calculated.	Experimental.	CHARGE, ETC.	Calculated.	Experimental.	Deg.	Experimental.	Calculated.	CHARGE, ETC.	Experimental.	Calculated.	CHARGE, ETC.
Charge 4 lbs. Solid Shot. Length of Gun 6-ft. 6-in. Windage ·169-in.			*Charge 3 lbs. Solid Shot. Length of Gun 6-ft. Windage ·12-in.*			P. B.			*Charge 2lbs. Solid Shot. Length of Gun 7-ft. Windage ·118-in.*			*Charge 1½ lbs. Solid Shot. Length of Gun 5-ft. Windage ·118-in.*
	343			345		¼		346			273	
	488			490		½		492			388	
	600			602		¾		605			477	
	696	695		699	699	1	700	702			554	
	781			785		1¼		788			623	
	859			863		1½		866		695	686	
	932			936		1¾		940			745	
	1000	1000		1004	1000	2	1000	1008			800	
	1065			1070		2¼		1074			853	
	1127			1132		2½		1136			903	
	1189			1192		2¾		1197			952	
	1245			1250		3		1255		1000	1000	
	1300			1306		3¼		1314			1045	
	1355			1360		3½		1366			1090	
	1408			1413		3¾		1419			1134	
	1459			1465		4		1471			1176	
	1510			1516		4¼		1522			1218	
	1560			1565		4½		1572			1260	
	1608			1614		4¾		1621			1300	
	1656			1662		5		1669			1340	
	1703			1709		5¼		1716			1379	
	1749			1756		5½		1763			1418	
	1795			1802		5¾		1809			1457	
	1840			1847		6		1854			1495	
	1885			1892		6¼		1899			1532	
	1929			1936		6½		1944			1569	
	1972			1980		6¾		1987			1606	

TABLE OF FIRST GRAZES—*continued*.

ORDNANCE, ETC. (BRASS GUNS.

3-POUNDER. (6 Cwt.)			3-POUNDER. (3 Cwt.)				3-POUNDER. (2½ Cwt.)			1-POUNDER. (2½ Cwt.)		
	Graze (Yards.)			*Graze* (Yards.)			*Graze* (Yards.)			*Graze* (Yards.)		
CHARGE, ETC.	Calculated.	Experimental.	CHARGE, ETC.	Calculated.	Experimental.	ELEVATION. Deg.	Experimental.	Calculated.	CHARGE, ETC.	Experimental.	Calculated.	CHARGE, ETC.
Charge 1 lb. Solid Shot. Length of Gun 6-ft. Windage ·095-in.			*Charge ¾ lb. Solid Shot. Length of Gun 4-ft. Windage ·095-in.*			P. B.			*Charge 10 oz. Solid Shot. Length of Gun 3-ft. Windage ·095-in.*			*Charge 0oz. Solid Shot. Length of Gun 5-ft. Windage ·073-in.*
	270					¼						
	384					½						
	472					¾						
	549					1						
	616					1¼						
	679	692				1½						
	737					1¾						
	792					2						
	844					2¼						
	894					2½						
	943					2¾						
	990	990				3						
	1035					3¼						
	1079					3½						
	1123					3¾						
	1165					4						
	1206					4¼						
	1247					4½						
	1288					4¾						
	1328					5						
	1366					5¼						
	1405					5½						
	1443					5¾						
	1480					6						
	1518					6¼						
	1555					6½						
	1591					6¾						

TABLE OF FIRST GRAZES—*continued.*

ORDNANCE, ETC. **(HOWITZERS.)**

10-INCH. (40 Cwt.)			8-INCH. (20 Cwt.)				24-POUNDER. (13¼ Cwt.)			12-POUNDER. (6½ Cwt.)		
CHARGE, ETC.	*Graze.* (Yards.)	*Flight.* (Seconds.)	CHARGE, ETC.	*Graze* (Yards.)	*Flight.* (Seconds.)	ELEVATION. Degs.	*Flight.* (Seconds.)	*Graze.* (Yards.)	CHARGE, ETC.	*Flight.* (Seconds.)	*Graze.* (Yards.)	CHARGE, ETC.
Charge 7 lbs. Length of Gun 5-feet. Windage ·16-inches.			*Charge 4 lbs. Length of Gun 4-feet. Windage ·16-inches.*			P. B.			*Charge 2½ lbs. Length of Gun 4-feet 7-inches. Windage ·125-inches.*			*Charge 1¼ lbs. Length of Gun 3-feet 9-inches. Windage ·122-inches.*
						¼						
						½						
						¾						
						1						
						1¼						
						1½						
						1¾						
						2						
						2¼						
						2½						
						2¾						
						3						
						3¼						
						3½						
						3¾						
						4						
						4¼						
						4½						
						4¾						
						5						
						5¼						
						5½						
						5¾						
						6						
						6¼						
						6½						
						6¾						
						7						
						7¼						
						7½						
						7¾						

TABLE OF FIRST GRAZES—*continued.*

13-INCH L. S. MORTAR. (*Shell* 200 *lbs.*)

ELEVATION.						CHARGE.	ELEVATION.					
Degrees.			Degrees.				45 Degrees.			Degrees.		
Fuze (Inches.)	*Graze* (Yards.)	*Flight* (Seconds.)	*Fuze* (Inches.)	*Graze* (Yards.)	*Flight* (Seconds.)	Lbs.	*Flight* (Seconds.)	*Graze* (Yards.)	*Fuze* (Inches.)	*Flight* (Seconds.)	*Graze* (Yards.)	*Fuze* (Inches.)
						2	11·00	697	2·42			
						2¼	12·50	840	2·75			
						2½	13·00	906	2·86			
						2¾	14·00	1054	3·08			
						3	15·00	1132	3·30			
						3¼	16·00	1244	3·52			
						3½	16·50	1317	3·63			
						3¾	17·00	1424	3·74			
						4	17·25	1490	3·79			
						4¼	17·50	1580	3·85			
						4½	18·50	1656	4·07			
						4¾	19·00	1744	4·18			
						5	19·25	1824	4·23			
						5¼	19·50	1900	4·29			
						5½	20·00	1950	4·40			
						5¾	20·50	2062	4·51			
						6	21·00	2 95	4·62			
						6¼						
						6½						
						6¾						
						7	24·00	2510	5·28			
						7¼						
						7½						
						7¾						
						8	25·00	2706	5·50			
						8¼						
						8½						
						8¾						
						9						

TABLE OF FIRST GRAZES—*continued.*

10-INCH L. S. MORTAR. *(Shell 92 lbs.)*

ELEVATION.						CHARGE.	ELEVATION.					
10 Degrees.			15 Degrees.				45 Degrees.			Degrees.		
Fuze (Inches.)	*Graze* (Yards.)	*Flight* (Seconds.)	*Fuze* (Inches.)	*Graze* (Yards.)	*Flight* (Seconds.)	Lbs.	*Flight* (Seconds.)	*Graze* (Yards.)	*Fuze* (Inches.)	*Flight* (Seconds.)	*Graze* (Yards.)	*Fuze* (Inches.)
						½	6·50	335				
						⅝	8·00	358	1·76			
·66	198	3·00				¾	9·00	464	1·98			
						⅞	10·00	534	2·20			
·77	278	3·50				1	10·50	638	2·31			
						1⅛	11·50	749	2·53			
·88	366	4 00	1·10	464	5·00	1¼	13·00	873	2 86			
			1.21	543	5·50	1⅜	13·50	956	2·97			
·93	451	4·25	1·32	590	6·00	1½	14·00	1028	3·08			
						1⅝	14·50	1123	3·19			
·99	482	4.50	1·48	685	6·75	1¾	15·00	1226	3·30			
			1·54	765	7·00	1⅞	16·00	1325	3·52			
1·04	559	4 75	1·59	805	7·25	2	16·50	1357	3·63			
						2⅛	17·00	1480	3·74			
1·10	597	5·00	1·65	884	7·50	2¼	17·50	1532	3·85			
						2⅜	18·00	1571	3·96			
1·15	602	5·25	1·70	960	7·75	2½	18·50	1700	4·07			
						2⅝	19·00	1780	4·18			
1·21	664	5·50	1·76	1070	8·00	2¾	19·50	1825	4 29			
						2⅞	20·00	1880	4·40			
1·26	764	5·75	1·87	1154	8·50	3	20·50	1916	4·51			
						3⅛						
						3¼						
						3⅜						
						3½						
						3⅝						
						3¾						
						3⅞						
						4	25·00	2485	5·50			

Table of First Grazes—*continued.*

8-Inch L. S. Mortar. *(Shell 46 lbs.)*

Elevation.						Charge.	Elevation.					
10 Degrees.			15 Degrees.				45 Degrees.			Degrees.		
Fuze (Inches.)	*Graze* (Yards.)	*Flight* (Seconds.)	*Fuze* (Inches.)	*Graze* (Yards.)	*Flight* (Seconds.)	Lbs.	*Flight* (Seconds.)	*Graze* (Yards.)	*Fuze* (Inches.)	*Flight* (Seconds.)	*Graze* (Yards.)	*Fuze* (Inches.)
						1/4						
						5/16	6·00	225	1·44			
						3/8	7·50	328	1·80			
						7/16	8·50	428	2·04			
·72	202	3·00				1/2	9·50	474	2·28			
						9/16	10·00	560	2·40			
·79	266	3.25				5/8	11·00	664	2·64			
			·96	427	4·00	11/16	12,00	762	2·88			
·84	351	3.50	1·08	485	4·50	3/4	12·50	801	3·00			
			1·20	513	5·00	13/16	13·50	859	3 24			
·96	413	4.00	1·32	559	5·50	7/8	14·00	960	3·36			
						15/16	14·50	1011	3·48			
1·14	461	4·75	1·56	690	6·50	1	15·00	1115	3·60			
						1 1/16	15·50	1156	3·72			
1·20	562	5.00	1.68	822	7·00	1 1/8	16·00	1262	3·84			
						1 3/16	16 50	1320	3·96			
1·44	664	6·00	1·80	827	7.50	1 1/4	17·00	1380	4·08			
						1 5/16	17.50	1446	4·20			
1.56	700	6.50	1·86	1004	7·75	1 3/8	18.00	1530	4·32			
						1 7/16	18·50	1600	4·44			
1·68	768	7·00	2·04	1012	8.50	1 1/2	19.00	1660	4.56			
						1 9/16	19·50	1720	4·68			
			2·10	1196	8·75	1 5/8						
			2·16	1337	9·00	1 11/16						
						1 3/4						
						1 13/16						
						1 7/8						
						1 15/16						
						2						

Table of First Grazes—*continued.*

5½-Inch Brass Mortar. *(Shell 16 lbs.)*

Elevation.						Charge.	Elevation.					
Degrees.			15 Degrees.				45 Degrees.			Degrees.		
Fuze (Inches.)	*Graze* (Yards.)	*Flight* (Seconds.)	*Fuze* (Inches.)	*Graze* (Yards.)	*Flight* (Seconds.)	Lbs.	*Flight* (Seconds.)	*Graze* (Yards.)	*Fuze* (Inches.)	*Flight* (Seconds.)	*Graze* (Yards.)	*Fuze* (Inches.)
						1						
						1¼						
						1½	5.50	155	1.32			
						1¾	6.00	198	1.44			
						2	6·50	255	1·56			
						2¼	7·50	316	1·80			
			·72	209	3·00	2½	8 00	380	1·92			
						2¾	8·50	426	2·04			
			·84	256	3·50	3	9·50	470	2·28			
						3¼	10·00	540	2·40			
			·96	375	4.00	3½	10·50	590	2·52			
						3¾	11·00	630	2·64			
			1·08	457	4.50	4	11·50	725	2·76			
						4¼	12·00	746	2·88			
			1·20	530	5.00	4½	12·50	800	3·00			
						4¾	13·00	910	3·12			
			1.32	561	5.50	5	13·50	935	3.24			
						5¼	14·00	1016	3·36			
			1.56	667	6·50	5½						
						5¾						
			1·68	709	7·00	6	15.00	1175	3.60			
						6¼						
						6½						
						6¾						
						7						
						7¼						
						7½						
						7¾						
						8						

TABLE OF FIRST GRAZES—*continued.*

4⅖-INCH BRASS MORTAR. (*Shell* 8 *lbs.*)

ELEVATION.						CHARGE.	ELEVATION.					
Degrees.			Degrees.				Degrees.			Degrees.		
Fuze (Inches.)	*Graze* (Yards.)	*Flight* (Seconds.)	*Fuze* (Inches.)	*Graze* (Yards.)	*Flight* (Seconds.)	Ounces.	*Flight* (Seconds.)	*Graze* (Yards.)	*Fuze* (Inches.)	*Flight* (Seconds.)	*Graze* (Yards.)	*Fuze* (Inches.)

TABLE OF FIRST GRAZES—*continued.*

13-INCH S. S. MORTAR. ***(Shell lbs.)***

ELEVATION.						CHARGE.	ELEVATION.					
20 Degrees.			45 Degrees.				50 Degrees.			73 Degrees.		
Fuze (Inches.)	*Graze* (Yards.)	*Flight* (Seconds.)	*Fuze* (Inches.)	*Graze* (Yards.)	*Flight* (Seconds.)	Lbs.	*Flight* (Seconds.)	*Graze* (Yards.)	*Fuze* (Inches.)	*Flight* (Seconds.)	*Graze* (Yards.)	*Fuze* (Inches.)
2·09	1263	9·50	4·47	1930	20·34	6				26·89	1166	5·91
			4·64	2053	21·12	6½						
			4·72	2190	21·47	7						
			4·94	2346	22·45	7½						
2·56	1746	11·66	5·10	2480	23·21	8				30·87	1455	6·79
			5·23	2600	23·80	8½						
			5·37	2734	24·44	9						
			5·49	2853	24·99	9½						
2·75	2069	12.50	5·60	2958	25·47	10				34·00	1775	7·48
			5·71	3026	25·94	10½						
			5·79	3150	26·35	11						
			5·88	3246	26·75	11½						
3·13	2534	14·25	5·96	3327	27·10	12	29.80	3435	6.55	37·00	2190	8·14
			6·03	3404	27·42	12½						
			6·10	3479	27·75	13						
			6·16	3552	28·02	13½						
3·35	2722	15·25	6·23	3617	28·32	14						
			6·28	3681	28·58	14½						
			6·39	3739	29·05	15						
			6·41	3797	29·15	15½						
			6·43	3849	29·26	16	32.00	3723	7·04			
			6·47	3901	29·45	16¼						
			6·52	3949	29·65	17						
			6·56	3997	29·84	17½						
			6·57	4040	29·88	18						
			6·61	4083	30·05	18½						
			6·64	4123	30·20	19						
			6·67	4160	30·36	19½						
			6·71	4200	30·50	20	32.50	4000	7.15			

Table of First Grazes—*continued.*

10-Inch S. S. Mortar. *(Shell lbs.)*

Elevation.						Charge.	Elevation.					
20 Degrees.			45 Degrees.				50 Degrees.			71 Degrees.		
Fuze (Inches.)	*Graze* (Yards.)	*Flight* (Seconds.)	*Fuze* (Inches.)	*Graze* (Yards.)	*Flight* (Seconds.)	Lbs.	*Flight* (Seconds.)	*Graze* (Yards.)	*Fuze* (Inches.)	*Flight* (Seconds)	*Graze* (Yards.)	*Fuze* (Inches.)
			4·29	1628	19·50	2¼						
			4·51	1760	20·50	2¾						
2·26	1338	10·31	4·62	1900	21·00	3						
			4·73	2150	21·50	3¼						
			4·95	2205	22·50	3½						
			5·11	2350	23·25	3¾						
2·73	1898	12·43	5·39	2500	24·50	4						
			5·50	2575	25·00	4¼						
			5·61	2653	25·50	4½						
			5,66	2725	25·75	4¾						
3·17	2324	14.41	5·72	2800	26·00	5				32 50	2000	7·15
			5·77	2900	26·25	5¼						
			5·83	3000	26·50	5½						
			5·88	3100	26·75	5¾						
3·33	2578	15·16	5·94	3200	27·00	6	29·25	3183	6·43	35·50	2215	7,81
			6·05	3275	27·50	6¼						
			6·16	3350	28·00	6½						
			6·27	3426	28·50	6¾						
3·58	2930	16·30	6·38	3500	29·00	7						
			6 43	3575	29·25	7¼						
			6·49	3650	29·50	7½						
			6·54	3725	29.75	7¾						
			6·60	3800	30·00	8	30·00	3599	6·60			
			6·63	3825	30·15	8¼						
			6·65	3850	30·25	8½						
			6·67	3875	30.35	8¾						
			6·69	3900	30·75	9						
			6·71	3950	30 50	9¼						
			6·76	*4000*	*30·75*	9½	30·50	3686	6·71			

TABLE OF FIRST GRAZES—*continued.*

ORDNANCE, ETC. **(CARRONADES.)**

68-POUNDER. (36 Cwt.)			42-POUNDER. (22 Cwt.)			ELEVATION.	32-POUNDER. (17 Cwt.)			24-POUNDER. (13 Cwt.)		
	Graze (Yards.)			Graze (Yards.)			Graze (Yards.)			Graze (Yards.)		
CHARGE, ETC.	Calculated.	Experimental.	CHARGE, ETC.	Calculated.	Experimental.	Deg.	Experimental.	Calculated.	CHARGE, ETC.	Experimental.	Calculated.	CHARGE, ETC.
Charge 5lbs. 10 oz. Solid Shot. Length of Gun 5-ft. 4-in. Windage ·15-in.		300	*Charge 3lbs. 8 oz. Solid Shot. Length of Gun 4-ft. 6-in. Windage ·075-in.*		270	P. B.	260		*Charge 2lbs. 10 oz. Solid Shot. Length of Gun 4-ft. Windage ·073-in.*	250		*Charge 2lbs. Solid Shot. Length of Gun 3-ft. 9-in. Windage .068-in.*
	290			273		¼		250			226	
	412			388		½		354			322	
	507			477		¾		437			397	
	589	580		554	550	1	520	508		460	462	
	662			623		1¼		571			520	
	728			686		1½		629			573	
	791			745		1¾		684			622	
	849	840		800	800	2	730	735		670	669	
	905			853		2¼		784			714	
	958			903		2½		830			757	
	1010			952		2¾		876			799	
	1060	1060		1000	1000	3	920	920		840	840	
	1108			1045		3¼		962			879	
	1155			1090		3½		999			917	
	1201			1134		3¾		1045			955	
	1246	1240		1177	1180	4	1100	1084		1000	992	
	1290			1217		4¼		1123			1028	
	1333			1260		4½		1162			1064	
	1376			1300		4¾		1200			1102	
	1417	1420		1340	1350	5	1260	1237		1150	1134	
	1459			1379		5¼		1274			1148	
	1499			1418		5½		1310			1202	
	1539			1457		5¾		1346			1236	
	1579			1494		6		1382			1269	
	1619			1532		6¼		1417			1302	
	1658			1569		6½		1452			1334	
	1696			1606		6¾		1486			1367	

TABLE OF FIRST GRAZES—*continued.*

ORDNANCE, ETC. **(CARRONADES.)**

18-POUNDER. (10 Cwt.)			12-POUNDER. (6 Cwt.)				6-POUNDER. (4¾ Cwt.)			-POUNDER. (Cwt.)		
	Graze (Yards.)			*Graze* (Yards.)			*Graze* (Yards.)			*Graze* (Yards.)		
CHARGE, ETC.	Calculated.	Experimental.	CHARGE, ETC.	Calculated.	Experimental.	ELEVATION. Deg.	Experimental.	Calculated.	CHARGE, ETC.	Experimental.	Calculated.	CHARGE, ETC.
Charge 1lb 8 oz. Solid Shot. Length of Gun 3-ft. 4-in. Windage ·061-in.		240	*Charge 1 lb. Solid Shot. Length of Gun 2-ft. 8-in. Windage ·066-in.*		230	P. B.	207		*Charge 10 oz. Solid Shot. Length of Gun 2-ft. 9-in. Windage ·05-in.*			*Charge . Solid Shot. Length of Gun . Windage -in.*
	215			186		¼		166				
	306			265		½		236				
	377			327		¾		292				
	439	440		381	400	1	360	340				
	494			429		1¼		384				
	544			474		1½		424				
	592			515		1¾		462				
	638	640		555	600	2	540	498				
	680			593		2¼		532				
	721			630		2½		566				
	761			665		2¾		598				
	800	800		700	700	3	630	630				
	837			733		3¼		660				
	874			766		3½		691				
	910			798		3¾		720				
	946	950		830	880	4		750				
	981			862		4¼		778				
	1015			803		4½		807				
	1049			923		4¾		835				
	1082	1100		953	1000	5		863				
	1115			983		5¼		891				
	1148			1013		5½		918				
	1180			1043		5¾		946				
	1212			1071		6		973				
	1244			1100		6¼		1000				
	1276			1129		6½		1026				
	1307			1158		6¾		1053				

GUNPOWDER.—*Charcoal,—Saltpetre,—Sulphur.*

Gunpowder may be defined, an Explosive Propellent. It is an artificial compound of saltpetre, sulphur, and charcoal, combined in various proportions, according to the practice of different countries:—

England,	75 Nitre,	10 Sulphur,	15 Charcoal.
Austria,	76 „	11 „	13 „
China,	75½ „	10 „	14½ „
France,	75 „	12½ „	12½ „
Russia,	70 „	11½ „	18½ „
Sweden,	75 „	9 „	16 „

The date of its discovery is involved in much obscurity. The most ancient authors differ in their accounts of this matter,—some of them confounding the discovery of the composition with its military application.

If we may believe their historians, and the relations of the missionaries, the invention, or at least its first application, is due to the Chinese. The earliest mention of gunpowder in Europe, is by Magnus Græcus, in a manuscript composed in the ninth century, and preserved in the University of Oxford. In this manuscript its composition is accurately described.

Its applicability to the purposes of war, is, with us, popularly ascribed to Bartholdus Schwartz, a monk of Goslar, in Germany, who flourished towards the end of the thirteenth century. It would appear, however, from the manuscript above quoted, that, not only the composition, but also the military application of gunpowder, ascends to a date far anterior to his time.

Manufacture.

The principal points to be attended to, in the manufacture of gunpowder, are the purity of the constituent ingredients, their combination and thorough amalgamation, the order of mixing them, and, lastly, the drying of the powder after it is made.

On the Strength of the Composition.

The explosive power of gunpowder depends fundamentally upon the quantity of elastic gas permanently generated, the rapidity of the inflammation, and the degree of heat to which it is raised.

The quantity of gas generated depends almost entirely on the purity of the charcoal, and its perfect combustion,—the nitre, being the cause of that combustion, furnishes one part of the gas from its own decomposed acid, as it does the other by converting the charcoal into carbonic acid. The property of the sulphur is to promote the rapidity of the inflammation, and, by its heat, to expand the fluid at the moment of explosion.

It is only necessary to add further, on this subject, that the inflammation and destruction of each grain of a given charge of powder is progressive—not simultaneous,—that with large charges this progressive destruction is never entirely effected within the bore of the gun,—that the elastic fluid disengaged by the explosion of the charge is composed of—

49	parts of	Carbonic acid gas
34	„	Azote, or Nitrogen
10	„	Hydro Carbonat
5	„	Nitrous acid gas
2	„	Sulphurous acid gas,—

and that the space occupied by the powder is to that occupied by the disengaged fluid as 1, to the cube of 16, or, in other words, that the charge after explosion occupies a space about four thousand times greater than it did in its concrete state.

On the Purity of the Constituents.

Of the *three constituents*, nitre, the principal, is, in its crude state, generally, if not invariably, found to contain a greater, or less proportion of common culinary salt, of which a small quantity is, from its affinity for moisture, sufficient to vitiate the properties of a large quantity of powder.—Hence, none but the very purest nitre should be used.

Grough sulphur, as it is received from Sicily, is mixed with a considerable portion of lime. Flowers of sulphur, or that which has undergone the process of sublimation, is the purest. A trifling degree of impurity in this ingredient is, however, of no moment; roll sulphur alone is therefore used in the government mills,—it is not so expensive as the sublimed.

With respect to the third ingredient, charcoal, greater nicety is required in its selection than is generally imagined. Its property depends almost entirely on that of the wood from which it is made. The softer descriptions containing, under equal bulks, less carbonat of potash, and other deliquescent salts, than the hard, they have from time immemorial been preferred for this purpose. Willow is recommended by Magnus Græcus. In this country white willow and alder are commonly used.

On Mixing and Grinding the Composition.

The first operation is to pulverize each ingredient separately, after which they are weighed, put into a tub—first a layer of charcoal, then a layer of saltpetre, next another layer of charcoal, and then a layer of sulphur, and so on in the same order—and mixed in a rude and general manner preparatory to a farther and more compact combination of their several particles by grinding.

In France this operation is effected by means of a pestle engine, or stamping mill, and, in other countries, by the rapid revolution of the mixture in a cask containing metallic balls. These contrivances are not to be recommended;—they are both inconvenient and dangerous when extensively employed, and the work is not so effectually performed by them as by the mill used in this country.

The incorporating mills employed in the government works are formed on the model of those used in cider manufactories. The cylinders, two in number, are of pure limestone, not brittle, nor easy of fracture, about five feet in diameter, and eighteen inches thick. They generally weigh about three tons each, the heavier the better. The bed is of the same material; it is usually about seven feet in diameter, and is surrounded by a wooden margin, two feet high. The axis of the mill rises from the centre of the bed, and the cylinders, each followed by a wooden rake or scraper, revolve round it at the rate of seven and a half revolutions in a minute. The cylinders move over a circular space two feet broad; they are consequently not equidistant from the axis, but are so arranged as to overlap each other about six inches. The motion is communicated to them either by horses, or by water,—each pair of cylinders requiring a six horse power.

A charge of the composition—forty-two pounds—being distributed on the bed, it is moistened, not wetted, with distilled water, to lay the dust which would otherwise fly off, and destroy the relative proportions of the several ingredients. The quantity of water required depends on the state of the atmosphere, generally from a tenth to a twelfth of the weight of the composition. The grinding, according to the velocity, requires from three to seven hours. It is on this long continued grinding, compounding, and blending together of the ingredients that the strength and goodness of the powder principally depends. The next part of the process is the removal of the mill-cake, as the composition is now called—an operation which requires the greatest caution, as it is during this part of the process that explosions usually take place. To guard against these accidents, it is absolutely necessary to prevent all contact between the bed and the cylinders, for which purpose a piece of thick hide should be carried before each.

ON THE PROCESS OF PRESSING AND GRANULATING.

The cake, as it is received from the mill, is gunpowder, and may be granulated. An additional degree of hardness, however, is essential to its durability. It is, therefore, still further condensed by pressure, either in a common screw press, or by means of Bramah's hydraulic engine. In the press it is also, by the interposition of copper plates, divided into separate strata about half an inch in thickness, that it may be more readily crushed preparatory to its granulation.

The granulating machinery, to which a horizontal motion is communicated, generally by water, consists of a number of vellum sieves, provided with tops and bottoms, arranged on an oblong platform. Into each of these sieves a portion of the crushed mill-cake is introduced, together with a couple of flattened discs, or blocks of lignum vitæ, by the friction of which, and the rotatory motion of the machinery, the powder is reduced into fragments, passes through the holes in the vellum, and is received in the receptacles beneath.

It remains to separate the grains according to the sizes desired. This is effected by a similar operation, only using treble sieves of strong silk or wire gauze, with different sized apertures. The dust is separated at the same time, and afterwards returned to the press.

The last part of the process is termed rolling,—the object being to remove the acute angles of the grains, which would otherwise be ground off in travelling and fill the casks with dust. Each class of powder is therefore rolled separately in a cylinder, moving on a horizontal axis, and so constructed as to retain the grains, and allow the dust, resulting from their mutual friction, alone to escape.

On the Process of Drying and Barrelling.

The powder thus completed, is, in appearance, perfectly free from moisture,—it contains however a large proportion of water, which must be separated by evaporation. In warm, dry climates a simple exposure of the powder to the sun's rays has been found sufficient. In France it is dried by passing heated air through a close chamber; and in some of the more ancient works in this country, it is exposed in shallow trays arranged round the sides of a room, heated by an iron pot, or gloom stove, to which the fire is applied from the outside of the building. More recently steam pipes have been introduced, and, by these means, every possible security, both real and imaginary, is attained.

After the powder has been thoroughly dried and cooled, it is again sifted, preparatory to barrelling,—a process absolutely necessary to guard against deterioration from the adhesion or caking of the grains. The dimensions of the several casks, and the quantities of powder put into each, are given under the head "Barrels."

Finally, each barrel is marked on the head *L. G; F. G; R. A*; or *R. S;* according as it contains large grained, fine grained, rifle arm, or re-stoved powder. Further, to distinguish the cylinder from the pit coal powder, the marks on the barrels containing the former are in red—those on the latter in blue paint.

Proof.

By the proof of gunpowder it is proposed to ascertain,—

I. Its projectile or available strength as compared with an approved sample, or given standard,—that on which the practice tables are formed, and,—

2. Its durability, the purity of its constituent parts, and the proportions in which they are severally employed.

ON THE ANALYSIS OF GUNPOWDER.

The durability and projectile force of gunpowder, we have seen, depend on the purity of the several ingredients employed in the manufacture, their thorough amalgamation, and the relative proportions in which they are respectively combined. To compare the available force of an unknown with that of a known powder therefore, we must commence by analyzing a sample of the former;—that is, we must resolve it into its constituent parts and test the purity of each separately.

Nitre is soluble in boiling water; sulphur and charcoal insoluble, consequently, by boiling the powder in four parts of distilled water, the nitre will be dissolved. It may then be crystalized, weighed, and tested by nitrate of silver and carbonat of potash to determine its purity. In a new sample we may thus readily ascertain whether the nitre is in sufficient proportion, and whether it has been sufficiently refined,—in a damaged one, whether the injury has arisen from fresh or salt water. The residue, composed of sulphur and charcoal, may be decomposed by spreading it on an earthern plate, and burning off the sulphur at the lowest possible degree of heat,—the charcoal will remain, still retaining, however, a small portion of sulphur. A more accurate process is to boil the mixture in a solution of pure alkali, by which a sulphuret will be formed. The residue is charcoal, which being dried and weighed completes the analysis.

ON THE PROJECTILE, OR AVAILABLE FORCE OF GUNPOWDER.

Analysis is, by some, held sufficient to determine not only the quality of any given specimen of gunpowder, the purity of its constituent parts, and the proportions in which they are combined, but even its projectile, or available force. By others, this mode of proof is regarded merely as auxiliary,—they consider a searching and rigid experimental test of its several properties absolutely indispensable. Various modes of experimental proof are adopted in different countries,—in this, flashing, combined with actual practice, and exposure to the atmosphere, is that pursued. Flashing consists simply in burning, on burnished copper, about two drachms of the given powder,—in this proof, it should neither emit sparks, nor otherwise foul the plate.

It is then tested as to its projectile strength, either by the gun, or the mortar eprouvette.

By the gun eprouvette, with a charge of two ounces. In this proof, with large grained powder, new from the mill, the index must describe an arc of 21 degrees;—with powder which has been issued and returned into store, or with regenerated or restoved powder, it must describe an arc of not less than 20 degrees, 30 minutes.

If the mortar eprouvette be used, and this is by many degrees more accurate, though not perhaps quite so convenient as the other, the 8-inch gomer is employed, with a charge of four ounces;—the elevation being 45 degrees, and the projectile a 68-pounder shot. With the first of the above powders, the range should not be less than 380 feet; with the other descriptions, not less than 350 feet.

Fine grained, or small-arm powder is proved with a carbine barrel and steel ball. The charge is two drachms, and the ball must, with new powder, perforate 15 or 16 half-inch elm boards, wetted and placed three quarters of an inch apart, the first being 39 feet 10 inches from the muzzle. With restoved powder, it must perforate from 9 to 12 of these boards.

Fine grained powder is likewise proved by the gun eprouvette. The charge, as in the case of large grained, is two ounces, and the arc described, with powder new from the mill, should not be less than 26 degrees;—with re-stoved, and all other descriptions of powder, it must not be less than 24 degrees.

The last proof consists in exposing a pound of the given powder, accurately weighed, to the atmosphere, for 17 or 18 days. If the ingredients be pure, and the amalgamation complete, it will not increase in weight, by attracting moisture from the air, more than one per cent.:—that is, 100 pounds of good powder should not imbibe more than 12 ounces of moisture.

Gyn.—*Exercise,—Tackle.*

Dimensions of Triangle Gyns.

(Large.)

Length of the Cheeks or Pry-pole,	20	Feet	6	Inches.
„ „ „ Windlass	6	„	9	„
Square „ „ „			9	„

(Small.)

Length of the Cheeks or Pry-pole,	16	Feet	3	Inches.
„ „ „ Windlass	5	„	11	„
Square „ „ „			8	„

Gyration.—*Pendulum.*

If a body revolve about an axis by a force applied at any point, there is a point in which, if all the matter of the body be collected, the same moving force applied at the former point will cause the latter point to revolve with the same angular velocity that the body revolves. This point is called the centre of gyration. And the momentum with which any particle in the body resists the moving force, is equal to the mass of that particle multiplied into the square of its distance from the axis of motion; therefore, the sum of the momenta of all the particles of the body may be found.

Again, the whole body being supposed to be col[illegible]ted in the centre of gyration, its momentum at that point is equal to the mass of the whole body, multiplied into the square of the distance of that point from the axis of motion. And these momenta must be equal, in order that equal angular motion may be produced by the action of the moving force in both circumstances. Therefore, from the equation thus formed, the unknown quantity, which is the distance of the centre of gyration from the axis of motion may be found. This term is found to be a mean proportional between the distances of the centre of gravity and centre of percussion, or of oscillation from the axis of motion.

If a strait line revolve about one of its extremities, the distance of the centre of gyration from the same extremity, will be equal to the length of the line multiplied into $\sqrt{\frac{1}{3}}$. If a circle or cylinder revolve about its centre or axis, the distance of the centre of gyration from that centre or axis, will be equal to the radius multiplied into $\sqrt{\frac{1}{2}}$. And if a sphere revolve about one of its diameters the distance of the centre of gyration from that of the sphere, will be equal to the radius multiplied into $\sqrt{\frac{2}{5}}$.

Hair Cloth,—*Artillery,*—*Magazine.*

Length 14 Feet 6 Inches. Breadth 11 Feet.
Weight 36 lbs.

Hand-Barrows,—*Battery,*—*Fortification.*

Length 5 Feet 3 Inches. Breadth 2 Feet.
Weight 19 lbs.

Hand-Spikes,—*Artillery,*—*Exercise,*—*Lever.*

Weight and Dimensions of Hand-Spikes.

(Large.)

Length of Square 2 Feet Diameter 1½ Inches.
Total 6 „ Square 3 „
Weight, of 10,—100 lbs.

HAND-SPIKES—*continued.*

(Small.)

Length of Square 1 Foot 9 Inches. Diameter 1¼ Inches.
Total 5 „ — „ Square 2¼ „
Weight, of 10,—64 lbs.

HARNESS,—*Artillery,—Drag Ropes,—Horses.*

It is proposed to substitute men's harnesss for drag-ropes with battering trains,—sixteen men to each set.

Length 11 feet. Weight 21 lbs.

Men's harness, with 4 bands, or loops to a set, is also issued to field guns and howitzers, when equipped for foreign service.

Horse harness is issued in proportion to the horses allowed for each nature of carriage, and comprises, besides the harness proper, the undermentioned articles,—

Whips (*short*).
Leggings.
Head-stalls (*chain reins*).
Nose bags (*canvas*).
Corn bags (2 *days corn*).
Forage cords.
Reaping hooks.
Water buckets (*leather*).

The horse of a gunner, or non-commissioned officer of Horse Artillery, mounted and accoutred, carries 18 stone 12 lbs.;—of a Light Dragoon, 18 stone 14 lbs.;—and of a Heavy Dragoon, 18 stone 11 lbs.

The weights carried by Artillery draft horses are as follow:—

Riding horse 15 stone 13 lbs.
Led „ 6 „ 4 „

In these weights, the driver, in complete marching order, is estimated at 10 stone 12 lbs, which was about the average weight of these men during the late war. Under the present system, from 2 to 3 stone additional must be allowed for the weight of the rider.

HORSES,—*Artillery*,—*Bridge*,—*Convoy*.

Distribution of Horses to the Carriages of Field, Horse, and Siege Artillery, Equipped for Foreign Service.

DISTRIBUTION.	ARTILLERY.			OBSERVATIONS.
	Field.	Horse.	Siege.	
ORDNANCE.				
GUNS:—				
24-Pounders	..	..	10	Field and Horse Artillery Ammunition Waggons for all natures of ordnance, both Guns and Howitzers, have six horses each.
18 "	10	..	..	
12 "	8	8	6	
9 "	8	8	..	
6 " (Heavy.)	8	..	..	
(Light.)	6	6	..	
3 "	6	6	..	
HOWITZERS:—				
10-Inch	..	..	10	
8 "	10	..	6	
24-Pounder	8	8	..	The transportation of the shot, shell, and general ammunition for a Battering Train. is not provided for either here, or in the detail of carriages required. The resources of the country in which the army is to operate must be put in requisition for these purposes,—the Flanders Waggons being reserved for the conveyance of the Laboratory Stores, and other perishable articles with a small portion only of the powder.
12 "	6	6	..	
CARRIAGES.				
GUN:— (Spare.)				
24-Pounder	..	..	6	
18 "	6	..	..	
12 "	6	6	4	
9 "	6	6	..	
6 " (Heavy.)	6	..	..	
(Light.)	6	6	..	
3 "	6	6	..	
TRANSPORTING:—				
Waggons, Flanders	..	..	4	
Store	6	6	4	
Platform	8	..	8	
(Spare.)	..	..	4	
Forge	6	6	4	
Ball Cartdge.	6	6	..	
Pontoon Carriage	6	..	..	
Carts, Store	2	2	..	
Hand	..	..	1	
Trench	..	..	1	

Horses in general average about 9 cwt. and occupy, standing at picket, 27 superficial feet, or 3 feet in breadth, by 9 feet in depth. Artillery horses should never be under 14½ hands high, neither should they be made to draw more than 3 cwt. not including the weight of the carriage. With great burthens, less weight than the above must be allotted to each horse, especially if they be of the description now provided for the artillery service, than with medium burthens. In a team of eight horses, the leaders have not the same power of draft as those nearer the carriage, and this disadvantage increases in proportion as the team lengthens.

Artillery carriages and waggons have frequently been loaded with 14 cwt. for 3 horses, and 20 cwt. for 4 horses, but these weights, however they may answer on English roads, are much too great for general service. Carriages of one construction will no doubt travel much easier than those of another, even when loaded with the same weights, and, where this mechanical advantage is greatest, there, of course, the heaviest burthen can be carried with the same number of horses; but under the greatest possible advantages, in respect both of roads and facility of movement in the construction of the carriage, I would not recommend a load exceeding 4 cwt. for each horse, in addition to the weight of the carriage itself. In transporting ammunition through bridle roads, and in situations through which wheel carriages cannot penetrate, it would not be advisable to load a horse with a weight much exceeding 300 lbs., or a mule with more than 250 lbs.

ON THE ACTIVE STRENGTH OR ANIMAL ENERGY OF MEN AND HORSES.

The force obtained by means of animal agency evidently varies, not only in different species of animals, but also in different individuals of the same *species*. And this variation depends, first,—on the particular constitution of the individual; and, secondly, upon the particular dexterity acquired by habit. It is plain, therefore, that such a variation cannot be subjected to any law, and that there is no expedient to which we can have recourse, but that of seeking mean results.

M. Coulomb, in estimating the strength of men and animals, expresses the quantity of action produced by their labour, by the product of the load they can carry, multiplied into the distance to which they can convey it in one day. If a man travel, therefore, unloaded, his quantity of action, that is, the product just mentioned, will be found to be a maximum; but the useful effect will be nothing. If we place a burthen upon him, he will produce a certain effect, though his real quantity of action will be diminished, and the greater the burthen the less will be his action, till, at length, when the load amounts to about 3 cwt., or twice the man's own weight, he cannot move; therefore, his action and effect will both be nothing. Between these extremes, there is a certain load which will give the maximum of useful effect.

If a man travel on a horizontal road for several days consecutively without a load, he can easily walk 31·07 miles in a day; and this multiplied into the weight of the man, which may be estimated at 160 lbs. will give 4971 lbs. for the daily quantity of action furnished by him under those circumstances. And this is expressed by 4971 lbs. carried one mile per day. If a certain load be added to the weight of the man, the product of the whole into the distance he can convey it during one day, will be less than that obtained above, and, consequently, will express a smaller quantity of action. M. Coulomb supposes the loss of action to be proportional to the load (and estimates it at 25 times its weight); and, on that principle, he obtains the following equation for the useful effect of the labour, viz. —the sum of the weights of the man and load multiplied into the distance he can convey it, is equal to the difference between the quantity of action furnished by a man unloaded, and the quantity lost by the load. The results of experiment being substituted in this equation, we from thence determine the maximum of useful effect to be obtained when the man carries a load of 135 lbs. besides his own weight. With this he can walk 10 miles per day, and hence the useful effect is expressed by 1350 lbs. carried one mile per day. But when a man carries a load to a certain distance on a horizontal road, and then returns unloaded for a new burthen, the maximum of useful effect is obtained when that load is 143 lbs.; this he can convey 7 miles per day, and hence the effect is expressed by 1001 lbs. carried one mile per day.

If a man, unloaded, ascend an easy stair, he can mount in one day to the vertical height of 1·82 miles. This multiplied by the weight of the man, viz. 160 lbs. will give 291 lbs. for the quantity of action furnished, which is expressed by 291 lbs. raised vertically to the heighth of one mile per day. And, by employing the principle before stated, it will be found that the maximum of useful effect produced, when a man ascends stairs, is obtained when he is loaded with 123·5 lbs. besides his own weight;—with this he can ascend to the vertical height of ·66 miles per day. Therefore his useful effect will be 81·5 lbs. raised one mile vertically per day.

The following are some useful results obtained in similar ways:—

1. A man carrying a load in a wheelbarrow, on horizontal ground, produces an useful effect equal to 1480 lbs. carried one mile per day.

2. A horse carrying a soldier and his equipments, weighing together 2 cwt., can go 25 miles on a horizontal road daily; therefore his useful effect in this respect may be expressed by 5600 lbs. carried one mile per day.

3. A man turning a cylinder by a winch, produces an effect equal to 168 lbs. raised to the height of one mile, vertically, per day. But when two men are employed together to turn a cylinder with two handles, at right angles to each other, the useful effect produced by each man is equal to 196 lbs. raised as before.

4. The force of a man in pulling or thrusting horizontally, is estimated at about 30 lbs.; and in these circumstances, he can move with a velocity of 1½ miles per hour.

5. A soldier loaded with from 45 to 60 lbs. can march 12 miles daily, and if we add to those loads the weight of the man, viz. 160 lbs. his daily action is equal to from 2600 to 2800 lbs. carried one mile per day.

6. A man marching in a mountainous country, with a load, can produce a daily quantity of action equal to 203 lbs. raised one mile.

7. A cart-horse can draw 326 lbs. through 25 miles daily on a horizontal road; therefore his useful effect, in this respect, may be expressed by 8150 lbs. carried one mile daily.

Horse Shoes.—*Artillery.*

Horse shoes are of four sizes,—the fourth or smallest size, is intended for mules.

1 size..	4 lbs. 10 oz.	3 size..	3 lbs. 10 oz.
2 „ ..	4 „ 6 „	4 „ ..	2 „ 14 „

The above are the average weights of a set of each size, with nails complete. When issued to Field Batteries, and Batteries of Horse Artillery on foreign service, they are packed in boxes, each containing 20 sets, together with a triple supply of nails. The average weight of each of these boxes is about 107 lbs.

HAWSER.—*Cable,—Cordage,—Rope.*

Weight, Dimensions, etc. of Hawsers.

MANUFACTURE. *(Machine Made.)*

	4-INCH. (108 Thds.)		4½-INCH. (132 Thds.)		5-INCH. (156 Thds.)		5½-INCH. (192 Thds.)	
FATHOMS.	Weight.	Strength.	Weight.	Strength.	Weight.	Strength.	Weight.	Strength.
1	3	7,168	4	9,172	5	11,200	6	13,552
2	7		9		11		13	
3	11		14		16		20	
4	15		18		22		27	
5	19		23		27		33	
6	22		28		33		40	
7	26		32		38		47	
8	30		37		44		54	
9	34		42		49		61	
10	38		46		55		67	
11	41		50		60		73	
12	45		55		66		80	
13	49		60		71		87	
14	53		64		77		94	
15	57		69		82		100	
16	60		74		88		107	
17	64		78		93		114	
20	76		93		110		135	
25	95		116		137		168	
30	114		140		165		203	
35	133		163		192		236	
40	152		186		220		271	
45	171		209		247		304	
50	191		233		276		339	
55	210		256		303		372	
60	229		280		332		407	
65	248		303		359		440	
70	267		327		366		475	
75	286		350		393		508	
80	305		373		441		543	
85	324		396		468		576	
90	344		420		496		611	
95	363		443		523		644	
100	382		467		552		679	
105	401		490		579		712	
110	420		513		607		746	
113	432		526		624		778	

Weight, Dimensions, etc. of Hawsers—*continued.*

MANUFACTURE, ETC. *(Machine Made.)*

Fathoms.	6-Inch. (228 Thds.)		6½-Inch. (264 Thds.)		7-Inch. (312 Thds.)		7½-Inch. (360 Thds.)	
	Weight.	Strength.	Weight.	Strength.	Weight.	Strength.	Weight.	Strength.
1	8	16,128	9	18,928	11	21,952	12	25,200
2	16		18		22		25	
3	24		28		33		38	
4	32		37		44		50	
5	40		46		55		63	
6	48		56		66		76	
7	56		65		77		89	
8	64		74		88		101	
9	72		84		99		114	
10	80		93		110		127	
11	88		102		121		139	
12	96		111		132		152	
13	104		121		143		165	
14	112		130		154		177	
15	120		139		165		190	
16	128		149		176		203	
17	136		158		187		216	
18	144		167		198		228	
19	152		177		209		241	
20	161		186		220		254	
25	201		232		275		317	
30	242		280		331		382	
35	282		326		386		445	
40	322		369		441		509	
45	362		415		496		572	
50	403		467		552		637	
55	443		513		607		700	
60	484		560		662		764	
65	524		606		717		827	
70	564		654		773		892	
75	604		700		828		955	
80	645		747		883		1019	
85	685		813		938		1082	
90	726		841		993		1146	
95	766		887		1048		1209	
100	807		934		1104		1274	
105	847		980		1159		1337	
110	887		1027		1215		1401	
113	911		1056		1248		1440	

Weight, Dimensions, etc. of Hawsers—*continued.*

MANUACTURE, ETC. *(Machine Made.)*

FATHOMS.	8-INCH. (408 Thds.)		8½-INCH. (468 Thds.)		9-INCH. (516 Thds.)		9½-INCH. (588 Thds.)	
	Weight.	Strength.	Weight.	Strength.	Weight.	Strength.	Weight.	Strength.
1	14	28,672	16	32,368	18	36,288	20	40,432
2	28		33		36		41	
3	43		49		54		62	
4	57		66		73		83	
5	72		82		91		104	
6	86		99		109		124	
7	103		115		127		145	
8	115		132		146		166	
9	129		149		164		187	
10	144		165		182		208	
11	158		181		200		228	
12	172		198		218		249	
13	187		214		236		270	
14	201		231		255		291	
15	216		247		273		312	
16	230		264		291		332	
17	247		280		309		353	
18	259		297		328		374	
19	273		314		346		395	
20	288		331		365		416	
25	360		413		456		520	
30	433		496		547		624	
35	505		578		638		728	
40	577		662		730		832	
45	649		744		821		936	
50	722		828		913		1040	
55	794		910		1004		1144	
60	866		993		1095		1248	
65	938		1075		1186		1352	
70	1010		1159		1278		1456	
75	1082		1241		1369		1560	
80	1155		1325		1461		1665	
85	1227		1407		1552		1769	
90	1299		1490		1643		1873	
95	1371		1572		1734		1977	
100	1444		1656		1826		2081	
105	1516		1738		1917		2185	
110	*1588*		1821		2008		2289	
113	*1632*		1868		2062		2352	

HOWITZER.—*Calibre,—Carriage,—Cartridge.*

Weight, Dimensions, etc. of English and French Howitzers, in English Measures.

DIMENSIONS, ETC.	HOWITZERS.					
	10-Inch.	8-Inch.	6-Inch.	4⅖-Inch.	24-Pounder.	12-Pounder.
ENGLISH.						
Diameter of Base Ring..	1·937	1·550	..	·706	1·000	·865
Muzzle	1·672	1·367	..	·706	·911	·724
Length, Feet	5·000	4·000	..	1·884	4 675	3·767
Calibres........	6·000	6·000	..	5·000	9·809	9·869
Bore,—						
Calibre	·834	·667	..	·377	·477	·382
Length, Feet.....	3·958	3·109	..	1·342	3·859	3·125
Calibres..	4·750	4·662	..	3·561	8·094	8·144
Chamber,—						
Depth of Segment	·313	·250	..	·094	·177	·142
Total....	·938	·792	..		·709	·567
Diameter, Greatest	·834	·667	..	·189	·477	·382
Least...	·625	·500	..	·189	·354	·284
Weight............ Cwt.	40·000	20·000	..	2 500	13·500	6·500
FRENCH.						
Diameter of Base Ring..	..	1·476	1·146	..	1·017	·623
Muzzle....	..			..		
Length, Feet	..	4·330	6·184	..	5·625	2·821
Calibres........	..	5·924	11·389	..	11·367	7·048
Bore,—						
Calibre	..	·731	·543	..	·495	·395
Length, Feet....	..	2·624	5·380	..	4·872	2·427
Calbres..	..	3·590	9·909	..	9·640	6·146
Chamber,—						
Depth of Segment	..			..		
Total ...	..	·656	·475	..	4·426	·229
Diameter, Greatest	..	·397	·397	..	·347	·272
Least...	..			..		
Weight............ *Cwt.*	..	24·000	18·000	..	11·500	2·000

ISINGLASS.—*Composition.*

Isinglass, a gelatinous substance, is prepared from the entrails of fish. The best, derived from the sturgeon, is prepared almost exclusively in Russia. It should be free from taste and smell, and be entirely soluble in warm water. It is used in laboratory works to give consistency to the composition.

LEAD.—*Ball,—Cartridge.*

Lead is seldom, if ever, found pure in its native state. Its colour is bluish white; it is remarkably soft and flexible, and melts at a temperature of about 612 degrees.

LEAGUE.—*Measure,—Mile,—Reconnoitering.*

The league varies in length in different countries. In England, it is equal to three statute miles, or 3000 geometrical paces. The French have three measures of this denomination,—the common league, equal to 4263 English yards,—the league of 25 to a degree, equal to 4860, and the marine league, equal to 6076 English yards.

In Brabant, the league is equal to 6076, and in Flanders to 6864 English yards. In Portugal, it is equal to 6760, and in Spain to 7416 English yards.

LEVEL.—*Distance,—Elevation,—Fortification.*

Levelling is the art of finding how much higher, or lower, a given point on the earth's surface is, than another point, on the same surface,—or, in other words, it is the art of finding the difference of their distances from the earth's centre.

The apparent level is a straight line, tangential to the true level, or surface of the earth. Every point in the former, therefore, except the point of contact, is higher or more elevated than its corresponding point in the latter.

1. *To find the Height of the Apparent, above the True, Level at a given Distance.*

Multiply the square of the given distance, in yards, by 2·57, and divide the product, by 1,000,000, for the height, in inches.

Required the difference between the true, and apparent level of an object, in the horizon, its distance from the observer being 1760 yards?

$$\text{Here, } \frac{(1760)^2 \times 2\cdot57}{1{,}000{,}000} = 7\cdot960832 \text{ Inches.}$$

2 *To find the Extent of the Visible Horizon, from a given Height.*

Divide the product of the given height, in inches, into 1,000,000, by 2·57, and take the square root of the quotient, for the extent or distance, in yards.

Required the extent of an observer's visible horizon, his elevation above the true level being 50 feet?

$$\text{Here, } \left(\frac{600 \times 1{,}000{,}000}{2\cdot57}\right)^{\frac{1}{2}} = 15{,}279 \text{ Yards.}$$

3. *To find the Distance of an Object, its Height being known.*

Compute the extent of the observer's horizon, by the preceding rule,—compute also the horizon of the object, and their sum will be the distance required.

Required the distance of a light-house, from a vessel just heaving in sight, the visible horizon from the top of the light house being 12 miles, and the height, from the water line, to the mast head of the vessel, 66 feet 4 inches?

$$\text{Here, } \left(\frac{796 \times 1{,}000{,}000}{2\cdot57}\right)^{\frac{1}{2}} + 21{,}120 = 21\cdot983 \text{ Miles.}$$

4. *To find the Height of an Object, its Distance being known.*

Subtract the visible horizon of the observer, from the known distance—the remainder will be the horizon of the object—and then compute, by rule 1, the height required.

Required the height of a vessel's mast, from the truck, to the water line, its distance, from a tower on the shore, 23 feet 11 inches high, being 19 miles?

$$\text{Here, } \frac{(33{,}440 - 10{,}560)^2 \times 2{\cdot}57}{1{,}000{,}000} = 37{\cdot}399 \text{ Yards.}$$

LEVER.—*Exercise,—Handspike,—Mechanics.*

Weight and Dimensions of Levers.

(Common.)

Length 6 Feet 6 Inches. Weight 10 lbs.

(Iron Shod.)

Length 4 Feet. Weight 7½ lbs.

LIGHT-BALLS.—*Artillery,—Composition.*

Light-Ball composition may be fixed either in smoke-ball or carcass cases. If fixed in the former, it will be necessary to enlarge the fuze-holes of the 4⅖ and 5½-inch shells,—the former to two, the latter to two-and-a-half inches in diameter. Carcass cases are available only when the balls can be projected at low angles.

Implements required:—

Hair Sieves.
Mixing Tables.
" Rubbers.
Iron Pots.
Water Tubs.
Copper Pans.
" Cylinders.
" Spatulas.
Loading Sticks.
Fuze Plugs.
" Drifts.
" Ladles.
" Mallets.
Kitt Kettles.
" Trivets.
" Brushes.

Materials required to complete 10 of each of the undermentioned Light-Balls.

MATERIALS.	LIGHT-BALLS.			
	10-Inch.	8-Inch.	5½-Inch.	4⅖-Inch.
Saltpetre, Ground ....lbs.	203·625	189·938	38·812	19·312
Sulphur, „ .... „	81·125	75·688	18·062	7·688
Rosin .... „	60·000	56·250	11·438	5·625
Mealed Powder.... ...... „	3·125	1·875	·500	·500
Quick-Match .... „	·312	·203	·125	·094
Kitt....................... „	4·500	4·000	2·500	1·500
Packing Twine .... „	·625	·500	·250	·125
Linseed Oil .... quarts	8 000	7·500	1·750	·875
Hessian .... yards	1·250	1·000	·750	·500

Magazine,—*Barrel,—Battery,—Fortification.*

Magazines should be placed in isolated situations. Extensive magazines in fortified places are both inconvenient and dangerous. They have often, by their explosion, caused the surrender of a place, otherwise well prepared to make a brave and obstinate defence. The powder provided for the defence of even the most inconsiderable place, should not, therefore, be concentrated in any one situation. Each of the principal works should have its own magazine, from which, the instant the enemy unmasks his plan of attack, every ounce of powder, not absolutely required for the daily service of the batteries, should be removed to others as distant as possible from his line of fire.

Field magazines are usually constructed in the interior, or against the sides of the traverses, in batteries, at about twenty, or twenty-five fathoms in rear of the platforms. If circumstances will admit, they should be established behind the returns of the epaulment, and should be otherwise well covered from the fire of the place. It is impossible to bestow too much care and attention on the construction of these magazines, and the communications from them to the several batteries. If the ground be favourable, the floors should be sunk below its surface, by which means much of the danger, that must always attend them will be effectually guarded against.

Marching.—*Convoy*,—*Pace.*

The rate at which troops can march must depend, on the number moving together, the state of the roads, the season of the year, and the distance to be accomplished before halting.

D'Antoni says, a regiment of cavalry may march seventeen miles in six hours, and that that distance may, in cases of necessity, be extended to twenty-two, or even to twenty-eight miles, in that time. Infantry, he says, in ordinary marches, which, continue six hours without a halt, move with a free, and natural step, at the rate of two miles and a third in an hour; and that a regiment, therefore, may, when the roads are good, accomplish fourteen miles in six hours.

General Scharnhorst says, a small detachment of cavalry may, when the horses are in good condition, accomplish at the gallop 2,500 paces in five minutes. If that distance is to be exceeded, he says, the horses must move at a trot, and that they cannot continue the movement, at that pace, beyond half an hour. He also says, 300 paces may be accomplished in one minute, 6,000 in twenty-five, and 9,000—nearly four miles—in thirty minutes, provided the party is to halt immediately afterwards. If a greater distance is to be traversed, it is impossible, he says, to move, even when the roads are good, more than twenty-four miles in twelve hours, without distressing the horses.

Infantry, he says, may accomplish four miles in an hour and a half, and that it is impossible to march more than five times that distance in ten hours. Large detachments, he says, cannot move at the above rate, and that, in an intersected country, an army cannot accomplish more than eight miles a day. The ordinary rate of marching for an army, he says, is from ten to twelve miles a day, but that in particular cases, from sixteen to twenty may be traversed, in that time, provided there are no defiles to pass, and that the army moves in several columns.

Artillery, General Scharnhorst says, may accomplish, when the horses start fresh and rest immediately afterwards, two miles in half an hour, four miles in an hour and a half, eight miles in four, and sixteen in ten hours. He further says, the horse artillery, in camp near Hanover, in 1791, traversed 350 paces in one minute, 3,900 in nine minutes and a half, 6,000 in twenty-two, and 12,000 in sixty minutes.

MATERIALS.—*Bridge,—Cordage,—Gravity.*

Bodies employed in building, are exposed to four different kinds of strain, or stress, each of which is investigated in the following observations,—

ON THE STRENGTH OF MATERIALS.

Every body, hard, soft, or elastic, is, in the aggregate, considered to be an assemblage, or combination of minute cohesive particles, or parallel fibres, and its strength is said to be absolute, or relative, according as the action of an extraneous force may affect the cohesion of those particles or fibres.

If a bar or beam of iron, or timber, or of any other material, be acted on by an extraneous force, fracture will ensue, provided the power of resistance exerted by the bar, or beam, be not sufficient to counteract the action of that force; and the power thus exerted by the body is the measure of its strength.

If an effort be made by any force to tear asunder the fibres of the body in the direction of their length, the strain thus exerted will be directly opposed to the cohesive power by which the particles of the body are held together. The power of a body to resist this kind of strain may, therefore, be considered as its absolute strength, and this will evidently be proportional to the number of fibres in the body, or to the area of its transverse section.

It appears, from Mr. Barlow's experiments on various kinds of wood, that a rod of any length, one inch square, will sustain the weight annexed to it in the following table, the weight of the rod itself not included.

Ash, English	17,000	Mahogany	8,000
Beech	11,500	Oak, Adriatic	14,000
Box	20.000	African	14,400
Deal, Christiana	11,000	Canadian	12,000
Memel	11,000	Dantzic	14,500
Elm, English	5,780	English	11,000
Fir, Mar Forest	12,000	Pear-tree	9,500
New England	12,000	Poon, East Indian	14,000
Riga	12,000	Pine, Pitch	10,500
Larch, Scotch	7,000	Red	10,000
Locust-tree	20,080	Teak	15,000

And it further appears from the experiments of Captain Brown and Mr. Telford, that a bar of malleable iron of the same dimensions will support, suspended from it 60,480, and from those of Muschenbroeck that an inch rope will support 1,000 pounds.

Hence, to find the strength of direct cohesion of *one of* these bodies of any given dimensions, multiply the area of its transverse section, in inches, by its corresponding tabular value, and the product will be the strength required, in pounds.

Mr. Barlow also finds the lateral adhesion of the fibres of fir, when they are drawn asunder in the direction of their length, to be equivalent to about 600 pounds on every square inch, and he considers the weights given in the above table to be such as will tear the bodies asunder in a minute or two,—that two-thirds of those weights will, if suspended from them for any considerable time, impair their strength, and that one-half is the utmost that each of the bodies should be required to support permanently.

If a weight be placed upon a body, the tendency of its particles will be to separate laterally, and, in this case, therefore, the power of resistance, or strength of the body, consists in the mutual cohesion of those particles, and the friction occasioned among them by the pressure. The powers of bodies to resist this kind of stress, or strain, is found to be in a higher ratio than the area of a transverse section of the material, but its precise value is as yet undetermined.

Various experiments have been made in reference to this subject, by Mr. Rennie and others, and the following table contains some of the results of their experience. Each of the bodies experimented on was in the form of an inch and a half cube, and the weights respectively annexed, such as were found sufficient to crush them.

Brick, Red	1,817	**Limestone, Compact** ..	17,354
Yellow	2,254	**Limerick**...	19,924
Chalk	1,127	**Purbec** ...	20,610
Freestone, Hard	21,254	**Marble, White veined**	21,738
Granite, Aberdeen ...	24,536	**Statuary**	13,632
Cornish	14,302	**Pavingstone, York** ...	15,856
Peterhead ..	18,636	**Sandstone, Dundee** ..	14,917

Elastic bodies, considered as combinations of parallel fibres, are found both by theory and practice, when pressed in the direction of their length, to be susceptible of inflection, and, in this case, Mr. Barlow determines the weight under which a rectangular column of timber of given elasticity, placed in a vertical position, will bend by the formula,—

$$\frac{\cdot 2056\, E.a.d^3}{l^2} = W.\text{—}$$

In which, *E* is an expression for the elasticity of a beam of the given kind of timber, the value of which must be taken from the following table;—*a*, for the thickness of the beam in the direction of the longest side of the section;—*d*, in the direction of the shortest side;—*l*, the length of the column;—and *W*, the weight required.

Acacia, English..	4,609,000	Iron, Malleable..	91,440,000
Ash, English....	6,580,000	Larch, Scotch....	4,200,000
Beech	5,417,000	Locust-tree	767,000
Birch, Common..	6,570,000	Norway Spars ..	5,830,000
A. Black..	5,700,000	Oak, Adriatic....	3,880,000
Deal, Christiana..	6,350,000	African	9,500,000
Memel	6,420,000	Canadian ..	8,595,000
Elm, English....	2,803,000	Dantzic	4,765,000
Fir, Mar Forest...	3,400,000	English.....	4,650,000
New England	5,967,000	Poon, E. Indian..	6,760,000
New Forest..	3,179,000	Pine, Pitch......	5,000,000
Riga........	5,314,000	Red	7,360,000
Iron, Cast	69,120,000	Teak............	9,660,000

The strength of a body, acted on by a disturbing force, in a direction transverse to its length, would appear to depend on the lateral cohesion and friction of its particles, on each side of the plane of fracture, and it would further appear that the power by which bodies resist this force of detrusion, is about double their absolute strength,—probably because the separation of the body is effected at two surfaces.

If a beam be attached to a wall at one end, and its fibres be not subject to compression, the effect of a weight, acting at the other end of the beam, will be, to cause it to separate from the wall, as if it turned on a hinge at its lower surface, close to the line of junction. In this case, each fibre is strained by the weight with a force which diminishes, as the distance of the fibre from the lower surface of the beam increases. Therefore, the cohesive power, exerted by the particles of any fibre, may be considered to be proportional to the distance of the fibre, from the bottom, and that cohesive force acts at the extremity of a lever, the length of which is equal to such distance. Consequently, the strength of any fibre is proportional to the square of its distance, from the bottom of the beam;—And if a longitudinal section of each, of two beams, be taken in a vertical plane, the strength of a fibre similarly situated in each will be proportional to the square, of the depth of the section. Therefore, the strength of the whole of each section will also be proportional to the square of the depth;—and because the strength of a beam is evidently also proportional to its breadth, the strength of the whole beam will be proportional to $b \,.\, d^2$, and its absolute resistance may be expressed by $b \,.\, d^2 \,.\, S$,—which is Mr. Barlow's formula. If b and d, the breadth and depth of the beam, be expressed in inches, the term S, which is a constant quantity, will express the resistance of a rod one inch square, and this resistance must be determined by experiment.

The strain produced by the weight will be expressed by the product of that weight into the length of the lever, at the extremity of which it acts,—that is, into the length of the beam itself, neglecting the effect arising from its deflection, which in architectural works is inconsiderable. And when the strength is just equal to the strain, these two expressions should be equal *to each other*. Therefore, to find the weight which a beam attached at one end to a wall will bear, without breaking, we have the equation.—

$$l.W = b.d^2.S.—$$

In which l, b, d are to be expressed in inches, and W and S in pounds. The only unknown quantity W may then be found.

The annexed is Mr. Barlow's table of the value of S, which he finds to be a constant quantity for each kind of wood, and which he determines from the above equation, when W is known from experiment.

Ash, English	2,036	Larch, Scotch	1,120
Beech	1,560	Locust-tree	3,400
Birch, English	1,900	Norway Spars	1,470
A. Black	1,500	Oak, Adriatic	1,380
Deal, Christiana	1,550	African	2,000
Memel	1,730	Canadian	1,760
Elm, English	1,030	Dantzic	1,450
Fir, Mar Forest	1,140	English	1,426
New England	1,100	Pine, Pitch	1,630
Riga	1,130	Red	1,340
Iron, Cast	8,100	Poon, East Indian	2,200
Malleable	9,000	Teak	2,400

If a beam of the same breadth and depth, and double the length, of the former, be supported by a prop in the middle, and strained by a weight at each end, equal to that which may be supposed to have been applied to the former beam, the extension of the fibres, over the prop, will be the same, in this case, as at the place of attachment, in the former. Consequently, the equation of equilibrium will be the same as before only substituting $\frac{1}{2}l$ for l and $\frac{1}{2}W$ for W. Because l, and W, now represent quantities, double of those which they represented before. Therefore, the formula, disregarding the deflection, becomes,—

$$\tfrac{1}{4}l.W = b.d^2.S—$$

If the beam be supported loosely on a prop at each end, and be loaded with a weight in the middle, the reaction of the props may be considered equal to the action of the weights, at the extremities of the beam, in the former case; and the action of the weight in the present case, equal to the reaction of the prop in the middle. Admitting this supposition, the equation of stability will be the same as before; but, on account of the obliquity of the reaction of the props, caused by the deflection, and the slipping of the beam between them, it is shewn by Mr. Barlow, that the strain in the latter case, is to the strain in the former, in the duplicate ratio of radius to the cosine of deflection. When, however, the deflection is small, it may be neglected, and the above equation employed.

Mr. Barlow also shews, that, since it requires four times as much weight to produce a certain deflection, in a beam supported at each end, as is required to produce the same deflection, in a beam of half its length, when supported at one end only, it will follow, that when a beam is firmly attached to a prop at each end, two thirds of the whole weight is employed in producing the central deflection, and one-sixth in producing that at each end. Consequently, the weight necessary to produce fracture at the middle of the beam, in this case, is, to that which is necessary in the former case, as 3 to 2. And the equation of stability, neglecting the deflection, becomes,—

$$\tfrac{1}{6}l \,.\, W = b \,.\, d^2 \,.\, S.\text{—}$$

If the weight be not in the middle of the beam, let *P* represent the product of the unequal distances of the weight from the two ends. Then, the equation, for a beam placed loosely on two props, will be—

$$\frac{P \,.\, W}{l} = b \,.\, d^2 \; S.\text{—}$$

And for a beam fixed at each extremity,—

$$\frac{2 P \,.\, W.}{3l} = b \,.\, d^2 \,.\, S.\text{—}$$

English Measures.

By the Statute 5th Geo. 4, cap. 74, it is enacted, that the Imperial Yard, Gallon, and Pound (Troy), shall be the only standard measures or units of extension, capacity, and weight;—and it is further enacted by the 5th and 6th Will. IV. cap. 63, that all articles sold by weight shall be sold by Avoirdupois Weight, except gold, silver, platina, and precious stones, which may be sold by Troy Weight; and except drugs, which may be sold by Apothecaries' Weight, when sold by retail.

LONG MEASURE.

12 Inches = 1 Foot
3 Feet = 1 Yard
5½ Yards = 1 Pole
40 Poles = 1 Furlong
4 Furlongs = 1 Mile
69 $\frac{1}{18}$ Miles = 1 Degree.

4 Inches = 1 Hand
6 Feet = 1 Fathom.

7·92 Inches = 1 Link
100 Links = 1 Chain.

Mechanics divide the inch into eighths and sixteenths. By others it is divided into tenths and hundredths.

SUPERFICIAL MEASURE.

144 Squ. Inches = 1 Squ. Foot.
9 ,, Feet = 1 ,, Yard
30¼ ,, Yards = 1 ,, Rod
40 ,, Rods = 1 Rood
4 Roods = 1 Acre.

10 Squ. Chains = 1 Acre
640 Acres = 1 Sq. Mile.

CUBIC MEASURE.

1728 Inches = 1 Foot
27 Feet = 1 Yard.

34·659 Inches = 1 Pint
69·318 ,, = 1 Quart.
277·274 ,, = 1 Gallon.

554·548 Inches = 1 Peck.
2218·192 ,, = 1 Bushel
10·269 Feet = 1 Quarter
51·345 ,, = 1 Load.

TROY WEIGHT.

20 Grains = 1 Scruple
2 Scruples = 1 Drachm
8 Drachms = 1 Ounce
12 Ounces = 1 Pound.

24 Grains = 1 Dwt.
20 Dwts. = 1 Ounce.

AVOIRDUPOIS WEIGHT.

16 Drachms = 1 Ounce
16 Ounces = 1 Pound
28 Pounds = 1 Quarter
4 Quarters = 1 Cwt.
20 Cwts. = 1 Ton.

ENGLISH MEASURES—*continued.*

14 Pounds = 1 Stone
8 Stone = 1 Cwt.

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36 Pounds = 1 Trs. Straw
56 ,, = ,, Hay
36 Trusses = 1 Load.

DRY MEASURE.

2 Pints = 1 Quart
4 Quarts = 1 Gallon
2 Gallons = 1 Peck
4 Pecks = 1 Bushel
8 Bushels = 1 Quarter
5 Quarters = 1 Load.

The Winchester bushel contained only 2150·42 cubic inches. Hence, to convert Winchester bushels into Imperial multiply by ·96945, and to convert Imperial bushels into Winchester, by 1·03152.

LIQUID MEASURE.

4 Gills = 1 Pint
2 Pints = 1 Quart
4 Quarts = 1 Gallon.

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36 Gallons = 1 Barrel
42 ,, = 1 Tierce.
63 ,, = 1 Hogshead
2 Hogsheads = 1 Pipe
2 Pipes = 1 Tun.

The old ale gallon contained 282, and the old wine gallon only 231 cubic inches. Hence, to convert ale gallons into Imperial, multiply by 1·01704, or to convert wine gallons into Imperial, by ·83311. And to convert Imperial into ale gallons multiply by ·98324, or to convert Imperial into wine gallons, by 1·20032.

Foreign Measures.

In the annexed Tables the Imperial Foot, Pound (Avoirdupois), Bushel, and Gallon, are severally compared as units with the equivalent or corresponding Measures of each of the specified countries. The value of each Foreign Measure, in terms of the unit, is shewn in the first column, and that of the unit in terms of the corresponding Foreign Measure, in the second column, opposite each country respectively.

LONG MEASURES.

England	1·0000	
Austria, Trieste (*Elle*)	2·2167	·4511
Venice (*Foot*)	1·1400	·8772
Bremen	·9434	1·0545

LONG MEASURES—*continued*.

China, Canton (*Cobre*)	1·2187	·8205
(*Foot*)	1·0542	·9485
Denmark, Copenhagen (*Rhineland Foot*)	1·0417	·9729
(*Elle*)	2·0000	·5000
Egypt (*Pik*)	2·2334	·4477
France (*Mètre*)	3·2809	·3048
(*Foot*)	1·0659	·9382
Greece, Patras (*Pik*, *Long*)	2·2500	·4445
(„ *Short*)	2·0834	·4799
Hamburgh (*Elle*)	2·9875	·3348
(*Foot*)	·9408	1·0629
India, Calcutta (*Cubit*)	1·5000	·6667
Bombay (*Hath*)	1·5000	·6667
(*Gaz*)	2·2500	·4445
Naples (*Palmo*)	·8650	1·1559
Netherlands (*Elle*)	3·2809	·3479
Persia, Bushire (*Guz*, *Common*)	2·0834	·4799
(„ *Royal*)	3·1250	·3200
Portugal (*Foot*)	1·0787	·9270
(*Vara*)	3·6000	·2778
Prussia, Dantzic	·9417	1·0619
Rome (*Foot*)	·9767	1·0238
(*Cana*, *Lesser*)	6·5283	·1532
(„ *Greater*)	7·3300	·1364
Russia, Petersburgh (*Archine*)	2·3334	·4286
Riga (*Elle*)	2·0000	·5000
(*Foot*)	·8992	1·1121
(*Clafter*)	6·0000	·1667
Sardinia, Cagliari (*Palmo*)	·8750	1.1441
Genoa („)	·8105	1·2338
Sicily, Palermo (*Palmo*)	1·2000	·8334
(*Canna*)	9·6000	·1042
Spain, Alicante (*Vara*)	2·4950	·4009
Barcelona *Cana*)	1·7500	·5720
Cadiz *Vara*)	2·7810	·3795
Sweden, Stockholm (*Elle*)	2·0000	·5000
(*Foot*)	·9737	1·0270
Turkey, Constantinople (*Arshim*)	2·3250	·4301
(*Endese*)	2·2500	·4445

LONG MEASURES—*continued.*

Tuscany, Leghorn (*Braccio*)	1·9150	·5223
(*Canna*)	7·6600	·1305
Tunis (*Pik*)	2·2084	·4524

DRY MEASURES.

England	1·0000	
Austria, Trieste (*Metzen*)	1·6705	·5986
(*Staro*)	2·2686	·4408
Venice (*Staga*)	2·2006	·4544
Vienna (*Metzen*)	1·9281	·5186
Bavaria, Munich (*Schaff*)	9·9672	·1003
Belgium, Antwerp (*Mudde*)	2·7512	·3634
Brussels („)	2·7509	·3635
Bremen (*Scheffel*)	1·9547	·5116
Brunswick (*Himpten*)	·8556	1·1680
Cassel (*Viertel*)	3·9230	·2549
Denmark, Copenhagen (*Toende*)	3·8234	·2626
Egypt, Alexandria, (*Rhebebe*)	4·2306	·2364
Cairo (*Kisloz*)	4·5745	·2186
France (*Boisseau de Paris*)	·3489	2·8719
(*Setier*)	4·1872	·2389
(*Litre*)	·0275	36·3637
(*Hectolitre*)	2·7512	·3634
Francfort (*Malter*)	2·4723	·4045
Hamburgh (*Scheffel*)	2·8965	·3453
Hanover (*Himten*)	·8548	1·1699
Lubeck (*Scheffel*)	1·0797	·9262
Mecklenburgh (*Scheffel*)	1·1676	·8564
Naples (*Tomolo*)	2·4340	·4108
Netherlands, Amsterdam (*Schepell*)	·7425	1·3468
Hague (*Sack*)	2·9510	·3389
Rotterdam (*Hoed*)	30·5452	·0327
Nuremburgh (*Simmern*)	9·2456	·1082
Persia (*Artaba*)	15·5112	·0645
Portugal (*Moyo*)	22·2884	·0449
(*Alquier*)	·3715	2·6917
Prussia, Berlin (*Scheffel*)	1·4945	·6691
Dantzic („)	1·5046	·6645

Dry Measures—*continued.*

Rome (*Rubbio*)	7·5209	·1329
Russia (*Chetwert*)	5·3593	·1866
(*Chetwerick*)	·6699	1·4928
Sardinia, Cagliari (*Starrello*)	1·3474	·7496
Genoa (*Mina*)	3·3931	·2941
Saxony, Dresden (*Scheffel*)	2·9100	·3436
Sicily (*Salma Generale*)	7·3164	·1367
(„ *Grosso*)	9.1133	·1097
Spain, Alicante (*Cahiz*)	6·7862	·1474
Barcelona (*Quartera*)	·2182	4·5829
Cadiz (*Cahiz*)	19·0982	·0523
Corunna (*Ferrado*)	·0445	22·6967
(*Fanega*)	1·4925	·6700
Sweden, Stockholm (*Tunna*)	4·0268	·2483
(*Kanna*)	·0719	13·9082
Switzerland, Berne (*Mutte*)	4·6254	·2162
Geneva (*Coupe*)	2·1364	·4687
Zurich (*Matte*)	2·2735	·4394
Turkey, Constantinople (*Kisloz*)	·9648	1·0365
Tuscany, Florence (*Stajo*)	·6509	1·5363
Wurtemburgh, Stutgard (*Scheffel*)	1·4553	·6871

Weights.

England	1·0000	
Austria, Trieste	1·2341	·8103
Vienna	1·2350	·8098
Venice (*Peso Grosso*)	·9507	1·0518
(„ *Sotile*)	1·5054	·6642
Belgium	2·2049	·4535
Bremen	1·0986	·9103
Brunswick	1·0294	·4971
China, Canton (*Catty*)	1·3334	·7500
Denmark, Copenhagen	1·1029	·9712
Egypt (*Rottolo Forforo*)	·9347	1·0698
(„ *Zaidino*)	1·3350	·7490
(„ *Mina*)	2·0700	·5988
(„ *Zaro*)	1·6700	·4830
France (*Livre de Marc*)	1·0793	·9265

WEIGHTS—*continued.*

France (*Usuelle*)	1·1024	·9071
(*Kilogrammo*)	2·2049	·4535
Frankfort	1·0300	·9708
Hamburgh	1·0680	·9363
Hanover	1·0730	·9319
Lubeck	1·0685	·9358
Malta (*Rottolo*)	1·7451	·5730
Morocco, Maggodore	1·7812	·5613
Naples, (*Contaro Grosso*)	1·9650	·5089
(„ *Piccolo*)	1·0600	·9434
Netherlands (Old Weight)	1·0893	·9180
(New „)	2·2049	·4535
Persia (*Maund Tabree*)	6·2500	·1600
(*Copra*)	7·2500	·1379
(*Shaw*)	13·2500	·0754
Poland (Old Weight)	·8331	1·2003
(New)	·8900	1·1236
Portugal (*Arratel*)	1·0119	·9882
Prussia	1·0330	·9680
Rome, Civita Vecchia (*Libra*)	·7477	1·3374
Russia, Petersburgh	·9026	1·1078
Riga		1·0849
Sardinia, Cagliari (*Contaro*)	93·0313	·0107
Genoa (*Peso Grosso*)	·7687	1·3000
(„ *Sotille*)	·6988	1·4310
(*Libbra*)	·8750	1·1428
Sicily (*Rottolo Grosso*)	1·9250	·5195
(„ *Sotille*)	1·7500	·5714
(*Libbra*)	·7000	1·4285
Spain, Alicante (*Arroba*)	27·3750	·0363
Barcelona	·8820	1·1337
Cadiz (*Pound of Castile*)	1·0150	·9851
(*Libbra*)	1·0144	·9857
Sweden (*Victualic*)	·9376	1·0666
(*Town*)	·7894	1·2667
Switzerland, Berne	1·1514	·8685
Geneva (*Heavy*)	1·2140	·8237
(*Light*)	1·0117	·9885

WEIGHTS—*continued.*

Switzerland, Zurich (*Heavy*)	1.1626	·8601
(*Light*)	1·0333	·9678
Turkey, Constantinople (*Ohe*)	2·8329	·3530
Tuscany, Leghorn	·7486	1·3358
Wurtemburgh, Stutgard	1·0314	·9655

LIQUID MEASURES.

England	1·0000	
Austria, Trieste (*Orna*)	12·5000	·0800
(*Barile*)	144·5446	·0069
Venice (*Miro*)	3·3561	·2979
(*Botta*)	142·6701	·0068
(*Begonzi*)	28·5340	·0350
(*Mastelli*)	14·2670	·0701
Belgium, Antwerp (*Stopen*)	6·0817	·1645
(*Aam*)	30·4085	·0328
Bremen (*Anker*)	6·4075	·1560
(*Ahm*)	25·6299	·0389
(*Oxhoft*)	48·3204	·0207
Denmark, Copenhagen (*Pot*)	·2124	4·7081
(*Anker*)	8·3311	·1200
(*Fuder*)	197·5604	·0051
France (*Litre*)	·2201	4·5434
(*Hectolitre*)	22·0000	·0455
Hamburgh (*Anker*)	7·9667	·1255
(*Ahm*)	31·8664	·0313
(*Fuder*)	191·1987	·0052
Naples (*Barile*)	9·1642	·1091
(*Salma*)	35·6144	·0280
(*Botti*)	109·9705	·0098
(*Carro*)	219·9410	·0045
Netherlands, Amsterdam (*Kan*)	·2201	4·5434
(*Vat*)	22·0000	·0455
Rotterdam (*Stoop*)	·5644	1·7718
Portugal, Lisbon (*Almude*)	3·6407	·2747
(*Tonnelada*)	189·3242	·0053
Prussia, Dantzic (*Quart*)	1·6522	·6052
(*Anker*)	8·2609	·1210

LIQUID MEASURES—*continued.*

Prussia, Dantzic (*Ahm*)	33·0437	·0303
Russia, Petersburgh (*Wedro*)	2·7076	·3693
Riga (*Anker*)	8·6088	·1162
(*Ahm*)	34·4385	·0290
(*Fuder*)	206·6812	·0048
Sardinia, Genoa (*Barrili*)	16·2997	·0613
(*Mezzarola*)	32·5995	·0306
Sicily, Palermo (*Barile*)	7·8083	·1280
(*Tonna*)	31·2332	·0320
Spain, Alicante (*Cantaro*)	2·5409	·3939
(*Arroba*)	3·1762	·3148
(*Tonnelada*)	254·0985	·0039
Barcelona (*Arroba*)	2·2702	·4405
(*Carga*)	27·2427	·0367
Cadiz (*Arroba, Lesser*)	3·1231	·3202
(„ *Greater*)	3·5407	·2824
Sweden, Stockholm (*Kannor*)	·5765	1·7346
(*Ahm*)	34·5041	·0290
Tunis (*Mettar*)	4·2696	·2342
(*Millerole*)	14·1000	·0709
Turkey, Constantinople (*Alma*)	1·1455	·8729
Tuscany, Leghorn (*Mezzetti*)	·1249	8·0064
(*Baccali*)	·2499	4·0016
(*Flasco*)	1·4998	2·0008
(*Barile*)	9·9973	·1000

MECHANICS.—*Exercise,—Friction,—Motion.*

Mechanics is that branch of Natural Philosophy which treats of the actions and effects of moving bodies one upon another. In other words, it is the science of equilibrium and motion.

ON THE ELEMENTS OF MACHINERY.

The mechanical principle by which a moving force is enabled to counterbalance, or overcome the resistance, or inertia of a superior force, or weight, is, that *part of the* resisting weight, or force, is supported by the machine, or engine, so that only the remaining part is opposed to the action of the motive force.

By machine, or engine, is understood a union, or combination of certain simple instruments, or contrivances, the actions, powers, and effects of which are either known, or can be readily determined.

Of these simple instruments, or contrivances, the Lever, the Wheel and Axle, and the Pulley, form one class, depending on one set of principles,—the Inclined Plane, the Wedge, and the Screw, another class, depending on another set of principles.

Levers.

Levers are of four kinds.

In the first kind, the rod is supported in some part of its length, on a fulcrum or prop, and the resisting, and moving forces, or the patient and agent, act at its opposite extremities. The operation of elevating, or depressing a gun, by means of a handspike, is an example of this kind of lever. The cheek of the carriage representing the fulcrum, or prop; the gun, the patient, or force to be overcome; and the man, the moving power, or agent.

The operation of running a gun up, after the recoil, exemplifies a lever of the second kind. In this case, the platform represents the fulcrum, the gun and carriage the patient, and the man the agent.

In the third kind, one end of the lever rests on the fulcrum, as in the second kind; but the patient and agent change places. The act of raising a ladder against the ramparts of a place, is a perfect illustration of this kind of lever. The ground on which one end of the ladder is planted, representing the fulcrum; the weight of the ladder itself, the patient, or resistance to be overcome; and the men employed in raising it, the moving force or agent.

The fourth kind of lever is, properly speaking, only a variety of the first. The difference consists in this, that the rod is bent, and the fulcrum applied at the angular point.

Now, by the theory of parallel forces, when an equilibrium subsists in a lever of the first kind, the power is to the resistance, as the distance of the latter from the fulcrum, is to the distance of the former from the same point,—or, the power multiplied into its distance from the fulcrum, is equal to the product of the resistance into its distance from the same point. And this rule holds good in respect to each of the other kinds, because, in each case, the power, resistance, and pressure on the prop, are three forces expressed by the same terms, but reciprocally interchanging values with each other, and of these three forces one is always equal to the sum of the other two, and acts in an opposite direction.

In each of the three kinds of levers, the resisting and moving powers are supposed to act in lines perpendicular to the arms to which they are respectively applied, and the levers themselves are supposed to be void of gravity, or weight; or, which is the same thing, the arms are supposed to be in equilibrio, independent of the weights, or prior to their application. If the power and resistance do not act in lines perpendicular to the arms of the lever to which they are applied, other lines must be drawn from the fulcrum at right angles to the lines of direction, of the forces respectively, on which the distances of the power, and resistance from the fulcrum being measured as before, the preceding proposition will still hold good;—and, if the arms of the lever be not in equilibrio, prior to the application of the weights, the weight of each arm must be multiplied into the distance of its centre of gravity, from the fulcrum, and added to the like side *of the above equation.*

If a number of levers be combined togethe power at the end of the first arm will be to the ance at the end of the last, as the continued p of all the short arms, to the continued product the long ones.

Wheel and Axle.

The wheel and axle is in principle analogou lever of the first kind, the fulcrum being at the of motion. In the case of an equilibrium, the the power is to the resistance, as the radius of th to the radius of the wheel,—or, as the circumf of the axle to the circumference of the wheel.

If two or more wheels and axles are com together by strings, or by teeth cut in their ci ferences, the power at the circumference of th wheel, is to the resistance at the circumference last axle, as the product of the radii of all the is to the product of the radii of all the wheels; the continued product of the number of teeth i axle, to the continued product of the number o in each wheel, supposing every wheel and axle t teeth.

Pulley.

In principle a moveable pulley is analogou lever of the second kind, the fulcrum being fixed extremity of the rope, the power at the extremity, and the resistance in the centre block. Then, when the two directions of the ro both parallel to the same diameter of the pulle power, is to its resistance, as 1 to 2, or, as the of the pulley to its diameter. And when severa leys are combined in two blocks, the same ra repeated as often as there are pulleys in the mo block; therefore, if *n* represent the number of p *in the* latter, the power, is to the resistance, as 1 so that if $n=3$, we have the power to the resistance as 1 to 6.

If a number of strings be made fast to immoveable points at one end, and each be made to pass under a moveable pulley, and the other end be attached to the block of the next pulley, and so on; then if a resistance be applied to the first block, and a power at the extremity of the last rope, the system will be analogous to a compound lever, of the second kind. Therefore, if n be the number of moveable pulleys, the ratio of the power to the resistance will be as 1 to $2\cdot n$, so that if $n=4$, we have the power to the resistance as 1 to 8.

Inclined Plane.

If a body is supported on an inclined plane, it is kept in equilibrio by three forces, that is the sustaining power, the power of gravity, and the re-action of the plane; which all concurring in the body, the ratios between them are, by the composition of forces, proportional to the three sides of a triangle coinciding with, or parallel to the directions in which the forces act. When the sustaining power acts in a direction parallel to the length, or parallel to the base of the plane, the triangle of forces is similar to that formed by the hypothenuse, base, and perpendicular of the inclined plane. In the first case, the sustaining power is to the weight of the body, as the height of the plane is to the length of the hypothenuse. And, in the second case, the sustaining power is to the weight as the height of the plane is to the length of the base.

Wedge.

The wedge is analogous in principle to an inclined plane, for on entering the material, the divided part appears to move along the slant side, precisely as a body moves up an inclined plane. If, therefore, the *impelling force* act in a direction perpendicular to the head of the wedge, that force, together with the resistance, and the re-action of the wedge, form three forces in equilibrio, which will be proportional to the sides of a triangle, drawn parallel to, or coinciding with, the directions in which the forces act. Consequently when the divided part turns on a joint at the angle of the wedge, the impelling power, is to the resistance, as half the breadth of the head of the wedge, is to its slant length. And when the divided part moves in a direction parallel to the head of the wedge, the impelling power, is to the resistance, as half the breadth of the head of the wedge, is to its perpendicular length.

Screw.

If a screw, by turning on its axis, enter any material, the parts contiguous to the sides of the threads, would appear to move along the sides, just as a body moves up an inclined plane. Therefore, in the case of an equilibrium, the moving power acting at the circumference of the screw, is to the resistance in the direction of the axis, as the distance between every two threads, measured in a direction parallel to the axis, is to the circumference of the screw. But if a wheel or lever be fixed to the axis, as is the case with the elevating screw of a gun, and the moving power be applied at the circumference of the one, or at the extremity of the other, the ratio of the circumference of the screw to the circumference of the wheel, must be compounded with that of the distance of the threads to the circumference of the screw, and the result will be, that the power is to the resistance, as the distance of the threads, to the circumference of the wheel.

Mile.—League,—Measure,—Pace.

Miles vary in length in different countries,—sometimes in the same country. In the annexed table the statute mile of England is compared as an unit, or standard, with that of each of the undermentioned countries; or, with the corresponding itinerary measures, of each of those countries respectively,—

England	1·0000	Netherlands (*Met. Mile*)	·6210
Arabia	1·2204	Oldenburg	6·1477
Bohemia	7·4642	Persia (*Parasang*)	3·4579
Brabant (*League*)	3·4523	Poland (*Short Mile*)	3·4523
China (*Li*)	·3591	(*Long* „)	4·6029
Dantzic	4·6153	Portugal (*League*)	3·8409
Denmark	4·6841	Prussia	4·6114
France (*L. de Poste*)	2·4222	Russia (*Werst*)	·6631
(*Kilometre*)	·6210	Saxony	5.6278
Germany (*Sh. Mile*)	3·8972	Scotland	1·1273
(*Long* „)	5·7534	Silesia	4·0244
Hamburgh	4·6841	Spain (*Com. League*)	4·2137
Hanover	6·6676	(*Royal* „)	2·6336
Hesse	5·9926	Suabia	5·7534
Holland	4·6026	Sweden	6·6477
Hungary	5·1779	Switzerland	5·2006
India (*Parasang*)	2·3009	Tuscany	1·0273
Ireland	1·2728	Turkey (*Berrt*)	1·0375
Italy	1·1506	Westphalia	6·9039

MINE.—*Artillery,—Fortification.*

Mines are either offensive or defensive. Offensive when employed by the besiegers; defensive when employed by the besieged. These latter are also called counter-mines.

ON THE DISPOSITION OF DEFENSIVE MINES

Engineers have proposed various systems of defensive mines, both permanent and temporary. Of these systems, those of Belidor, Mouzé, and Marescot, are the most celebrated. Every system of defensive mines, however it may vary in the disposition of its several details, must conform to the general outline of the works and the configuration of the ground, in advance of, and beneath which, it is established. In other words, the galleries and communications must severally occupy those situations from which the besieged can most readily drive branches and establish chambers under the besiegers' batteries and approaches.

Belidor employed, in his system, three principal galleries,—one under the terreplein of the covered-way,—another, called the gallery of envelope, at the foot of the glacis,—and a third behind the escarp revetments. The main gallery, established under the covered-way, he connected, at certain intervals, with the gallery of envelope, by direct galleries or communications, and, from the gallery of envelope, he threw out other direct galleries, called listeners, still further towards the enemy. He also sometimes connected the main and escarp galleries by communications under the ditches.

Mouzé employs but one principal gallery, which he places beneath the terreplein of the covered-way, in contact with the counterscarp. With this gallery he combines a series of longitudinal and transverse galleries, and galleries of communication so directed and disposed that an enemy can attack them neither in front nor flank, without exposing his operations to the full effects of the defensive chambers. Beneath each salient angle he makes three defensive dispositions,—one immediately in front of the salient, and the other two more in advance. The first disposition is arranged in a single tier, the others in two or three tiers, according to the nature of the soil. He also proposes that the chambers of the more advanced mines shall be isolated, or independent in their action; and that the chambers directly in front of the salients shall act in combination, or simultaneously.

General Marescot, in his system, substitutes relieving vaults, or casemates, for the gallery under the terreplein of the covered-way; and employs neither transverse galleries nor a gallery of envelope. He disposes his galleries of communication and listening galleries in the form of a species of net-work, so contrived and arranged that in what direction soever the enemy shall advance in his approaches towards the crest of the glacis, he will be met, either in front or flank, by the besieged. Like Mouzé, he also defends the glacis by three distinct dispositions,—the first, arranged in three tiers, is directed against the third parallel,—the second, also arranged in three tiers, is directed against the fourth parallel and the intermediate works,—and the third, arranged in a single or double tier, as occasion may require, against the enemy's breaching and counter batteries.

ON THE CONSTRUCTION OF MINES.

Mines are either offensive or defensive, temporary or permanent. Offensive mines are usually lined with timber,—defensive, with timber or masonry, according to circumstances. In either case the mode of construction is precisely the same.

Excavations employed in mining are of two kinds, the one vertical, the other either horizontal or inclined to the horizon. If the excavation be vertical, it is called a shaft,—if horisontal, or inclined to the horizon, a branch or gallery, according to its dimensions and intended object. Branches and galleries are also distinguished into ascending or descending, according as they approach to, or depart from, the horizon in their onward march. The recess or cavity formed to receive the charge is called the chamber of the mine, and the shortest line that can be drawn from the centre of this recess to the surface of the ground, the line of least resistance.

The excavation formed by the explosion is called the crater or funnel of the mine, and the solid removed is, according to Valière and Cormontaigne, a paraboloid, the base and focus of which are coincident with the plane of explosion and centre of the *charge. The centre of* the charge is also sometimes called the focus of explosion; and the point at which the match is applied, the focus of ignition. Also a line drawn from the focus of explosion to the edge of the crater, or of the plane of explosion, is called the radius of compression.

If a shaft is to be sunk merely for the purpose of demolition, its dimensions cannot be too contracted. It is found however from experience, that if the shaft be of less dimensions, than two feet by three, a miner cannot proceed after sinking six feet,—and it has been farther found, that time will be gained if the latter of these dimensions be increased by six inches. In the field, shafts exceeding three feet by four in the clear, are seldom required,—they are sufficiently large for all ordinary purposes.

Branches seldom exceed two feet six inches in width, by three feet six inches in height. Branches only twenty inches square have been driven; but in such cases, the progress made was slow in proportion, not exceeding from six to twelve inches in an hour, according to the nature of the soil. Galleries lined with masonry are usually made six feet in height, by four feet six inches in width. Temporary galleries seldom exceed four feet six inches in height, by three feet in width,—and it is found, that the air is unfit for respiration, in the larger galleries at a greater distance from the bottom of the shaft than twenty-five fathoms —in those of medium dimensions at a greater distance than twenty, and in the smallest than fifteen fathoms. The chambers are made from two to three inches larger in every direction than the box or coffer in which the charge is lodged, and are usually established at the extremity of a branch, or at the bottom of a shaft. In either case, they must not be cut in the prolongation of the original excavation, but at right angles to it.

In order to protect the loaded hose from injury, especially in stopping or tamping the mine, it is enclosed in a wooden tube called an auget or hose pipe, extending from the centre of the charge, or focus of explosion, at which point one of its extremities must be secured, to the focus of ignition. The hose itself is usually made of coarse linen or serge one inch in diameter. It requires about one pound of powder to fill every four feet of its length—an operation which is most readily managed from a height.

The frames employed in sinking shafts, or driving branches and galleries, are usually placed at from three to four feet apart, according to the nature of the soil. In a soil of medium tenacity, a miner, at work, may be heard at a distance of from twelve to fifteen fathoms,—and the noise made in fixing the frames may often be heard at a distance of from twenty to twenty-five fathoms.

If the dimensions of a proposed shaft do not exceed three feet by four, the scantling for the frames need not exceed three inches in depth, by four and a half in breadth. Scantling, four inches in depth, by five and a half in breadth, will be amply sufficient, under ordinary circumstances, to resist the lateral pressure of the earth in a shaft not exceeding five feet by six. The stancheons, and groundsils of gallery and branch frames are usually made of square scantling. If a gallery is not to exceed four feet, or five feet six inches in width, five-inch scantling will suffice for the stancheons and groundsils of the former, and six-inch scantling for those of the latter. Branch frames seldom require scantling exceeding four inches square. In the galleries and branches the pressure is principally on the capsils of the frames. The depth of each capsil must consequently be proportionally greater than its breadth by one-third, or one-half, according to the tenacity of the superincumbent earth. In like manner, the top sheeting of the galleries and branches is usually cut from two, or two and a half inch plank, while inch or inch and a half plank is sufficient for the side *sheeting, or for* the sheeting of the shafts.

On the Charges of Mines.

If a charge of gunpowder be exploded in an adhesive, and compressible soil, of indefinite extent, its effect will be, to drive back in every direction, the earth in immediate contact with the chamber,—to convulse and disturb the homogeneity of the soil to a still greater distance,—and, finally, to produce a vibratory motion, limited in extent only by the elasticity of the resisting medium. On this principle, General Marescot distinguishes three concentric spheres of action, in the mass of earth in which a mine is sprung;—the sphere of activity, which extends from the centre of the charge to that point at which all action ceases,—the sphere of friability, or that portion of the sphere of activity, within which the particles of the soil are affected by a motion of translation,—and the sphere of rupture, the most important of all, within the limits of which, cavities are burst in, galleries and branches injured, and revetments, et cetera, overwhelmed and destroyed.

It is manifest, therefore, if the sphere of activity be cut by a plane passing without the sphere of friability, that the only external effect produced by the explosion of the charge will be a vibratory motion in the particles beneath that plane, and that this motion will increase in intensity, in proportion as the intersecting plane approaches the confines of the latter sphere. On the other hand, if the sphere of activity, be cut by a plane passing within the sphere of friability, it is equally evident, that the effect of the charge will no longer be confined to the production of a vibratory motion in the particles beneath the plane, but that an external excavation, or funnel, will be formed, by the translation of those particles, and that the magnitude, or volume of this excavation will be, ceteris paribus, in proportion to the charge. In this case also, the intersecting plane is coincident with the base of the solid removed; and, consequently, identical with the plane of explosion.

Hence, mines are distinguished into under, ordinary, and surcharged mines, according as the radius of the funnel is less, equal to, or greater, than the line of least resistance, and are charged with reference to the position of the chamber, the resistance to be overcome, and their proposed effect. In other words, they are charged with reference to the length of the line of least resistance, the nature of the soil through which that line passes, and the diameter of the proposed funnel, or plane of explosion,—each of which conditions is, in the case of an ordinary mine, fulfilled by the expression $C = 1{\cdot}9\, l^3 .\, n$,—in which l represents the line of least resistance, in feet, and n, the quantity of powder, in pounds, required according to the nature of the soil, to raise a cubic yard of the solid.

The annexed table exhibits the value of n for each of the several kinds of soil therein specified.

Light Earth mixed with Sand	1·375
Common Earth	1·500
Fine Sand mixed with Clay	1·625
Hard and Strong Sand	1·875
Clay or Fat Earth	2·000
Wet Sand	2·125
Earth mixed with Gravel	2·250
Clay mixed with Loam	2·500
Sandstone or Rock................	3·625
Brick-work, or New Masonry	3·750
Old and Good Masonry............	4·063

In a soil of uniform tenacity, the effect of each of these charges will be to shake the ground in all directions around the crater to a distance equal to the line of least resistance, and to burst in branches or galleries situated in the same horizontal plane as the chamber at a distance equal to once and a half that line. The besieged can therefore employ surcharged mines only at the risk of destroying their own works.

If the mine is not to be sprung immediately on being loaded, or if the soil surrounding the chamber be not free from damp, the security of the charge requires that it should be lodged in a box or coffer, which, if the dimensions of the branch will admit of it, is usually prepared above ground, and conveyed empty to the chamber, or, it may be conveyed to the chamber in parts, and be there put together. In conformity with the theory of inflammation, the form of this box should be that of a sphere, but in practice the cube is adopted. Its capacity, and thence the dimensions of its side, are determined from the known fact, that a pound of powder in a loose state, occupies about thirty cubic inches. Consequently if the charge in pounds be multiplied by thirty, the product will be the capacity or volume of the required coffer, and the cube root of that product will be the measure of its interior side in inches.

It is next to be observed that, in order to confine the effects of the charge as much as possible within the limits of the proposed plane of explosion, the branch at the extremity of which the chamber is established, must be tamped or stopped to an extent equal to twice the line of least resistance; or if the chamber be situated at the bottom of a shaft, that the whole extent of the shaft must be tamped. It frequently happens however, that these operations cannot be completed for want of time, or from other causes, and in such cases, the charge must be augmented in proportion as the extent to which the tamping should be carried, is diminished. If the charge be encreased by one-fourth, the extent of the tamping, it is supposed, may be diminished one-third,—if by one-half, the tamping may be diminished two-thirds, and that if the charge be doubled, that the tamping may be dispensed with altogether.

Mortar.—*Cartridge,*—*Chamber,*—*Gunnery.*

Weight, Dimensions, etc. of Land and Sea-Service Mortars.

DIMENSIONS, ETC.	MORTARS.				
	13-Inch.	10-Inch.	8-Inch.	5½-Inch.	4⅖-Inch.
LAND SERVICE.					
Diameter of Base Ring					
Muzzle					
Length, Feet	3·047	2·344	1·875	1·259	1·059
Calibres	2·811	2·811	2·811	2·864	2·809
Bore,—					
Calibre	1·084	·834	·667	·469	.377
Length, Feet	1·084	·834	·667	·527	·471
Calibres	1·000	1·000	1·000	1·124	1·249
Chamber,—					
Depth of Segment					
Total	1·084	·834	·667	·469	·377
Diameter, Greatest	1·084	·834	·667	·469	·377
Least	·625	·417	·334	·259	·225
Weight Cwt.	36·500	16·500	8·750	1·500	1·000
SEA SERVICE.					
Diameter of Base Ring					
Muzzle					
Length, Feet	4·401	3·802	..	..	..
Calibres	4·059	4·559	..	..	..
Bore,—					
Calibre	1·084	·834	..	..	..
Length, Feet	3·000	2·084	..	..	..
Calibres	2·587	2·499	..	..	..
Chamber,—					
Depth of Segment					
Total	1·084	·834	..	..	..
Diameter, Greatest	·813	·625	..	..	..
Least	·609	·470	..	..	..
Weight Cwt.	100·500	52·000	..	..	..

Mortar-Beds.—*Carriage,—Mortar,—Platform.*

Weight, Dimensions, etc. of Land and Sea Service Mortar-Beds.

DIMENSIONS, ETC.	MORTARS.				
	13-Inch.	10-Inch.	8-Inch.	5½-Inch.	4⅖-Inch.
LAND SERVICE.					
(Old Pattern.)					
Height	2·083	1·583	1·250	·750	·709
Length	5·667	4·417	3·500	2·583	2·417
Breadth	3·334	2·583	2·083	1·250	1·250
Weight ... Cwt.	48·750	22·000	11·250	1·000	·750
(New Pattern.)					
Height	2·083	1·583	1·250	..	..
Length	5·459	4·334	3·250	..	..
Breadth	3·875	3·375	3·083	..	..
Weight ... Cwt.	33·000	16·500	7·750	..	..
SEA SERVICE.					
Height	3·292	2·792	..	..	..
Length	7·209	7·083	..	..	..
Breadth	4·625	3·667	..	..	..
Weight ... Cwt.	83·500	55·000	..	..	..

OBSERVATIONS ON THE EMPLOYMENT OF MORTARS.

Mortars are employed to dismount an enemy's artillery, to overthrow and set fire to his works, to produce havoc and disorder among his troops, and, in the case of a bombardment, to penetrate the roofs of magazines, casemates, and such other buildings as have not sufficient strength to resist the momentum of their projectiles.

The powers of the 10-inch mortar are, generally speaking, adequate to these purposes. Hence, on principles of economy, 13-inch mortars are seldom employed in modern battering trains. If the object be merely to set fire to an enemy's works, the 13-inch mortar has, from the superior capacity of its shells, a decided advantage over the 10-inch; and, for this reason, the armament of every bomb-vessel invariably includes a mortar of that description.

In the larger mortars the initial velocity of the shell increases in proportion to the charge. To obtain the greatest initial velocity, therefore, the chamber should be filled with powder. If the shell be surrounded with sifted earth or sand the inflammation of the charge will be more rapid, and the generated fluid more abundant and elastic; and, consequently, the initial velocity of the projectile will be thereby still further increased. By increasing the elevation an addition will also be made to the initial velocity, because, in this position of the mortar, the resistance opposed to the explosion is still further increased; and the fluid generated in the chamber will consequently acquire greater density before the shell begins to move.

It has been found by varying the charge in the same mortar that there is a particular elevation with each charge that gives a longer range than can be obtained with the same charge at any other elevation, and that the elevations which give the longest ranges differ very materially in two mortars of different calibres, but of similar proportions, and charged with quantities of powder proportionate to the weights of their respective shells, and to the capacities of their respective chambers.

Motion.—*Fluids,—Mechanics,—Gunnery.*

Motion is either equable or variable. Equable if the body in motion move with an uniform velocity, or pass over equal spaces in equal times. Variable if the velocity of the moving body be either accelerated or retarded.

ON THE LAWS OF MOTION.

Every body has a natural tendency to continue in its present state, if at rest, it will continue in a state of rest,—if put in motion by an external impulse, it will continue to move uniformly in a rectilinear direction until a change is effected in its motion by the agency of some mechanical force.

Changes or alterations of motion effected in bodies by external forces are always proportional to those forces, and in the direction of the right lines in which they act.

Action and re-action are equal and contrary,—that is, by action and re-action equal changes of motion are produced in bodies acting on each other, and these changes are directed towards opposite and contrary parts.

Equable or uniform motion is produced by a single impulse communicated to a body, and the velocity of a body in motion being measured by the space uniformly described in a given time, it follows that, when a body moves with an uniform motion, the spaces it describes are proportional to the times. But if several bodies move with different velocities, during different times, the spaces they describe are proportional to the velocities multiplied into the times of motion respectively; which is expressed by the formula $S \propto v.\ t.$

Accelerated motion is the result of the continued action of a moving power on a body subject to its influence, and it may be considered as produced by a *succession* of equal impulses at the end of indefinitely small portions of time. Each new impulse producing an equal increment of velocity, the velocity at the end of any given time will be proportional to the time; the spaces described in the successive instants of time will form a series of terms in arithmetical progression, beginning with zero, and increasing by unity, and the sum of such a series is equal to the whole space described. But the same space would have been described in the same time, if the body had moved uniformly with a velocity which is a mean of all the variable velocities, and that mean velocity is half the greatest, which may be represented by half the time of motion. Therefore, substituting this expression for the velocity, in the formula of uniform motion; viz. $S \propto v.t.$ we have $S \propto \frac{1}{2} t^2$; whence $S \propto t^2$. That is, the spaces described by a body urged by an accelerative force are proportional to the squares of the times of motion. Near the surface of the earth a body falls through $16\frac{1}{12}$ feet by the action of gravity in one second of time; therefore, the spaces described by a falling body in any given time may be found by the formula, $S \propto t^2$. And the velocity generated in a body urged by the action of gravity during one second, being such as would carry the body through $16\frac{1}{12}$ feet in the same time if the body had moved uniformly with half that generated velocity, twice that space, or $32\frac{1}{6}$ feet, will express the velocity generated by gravity at the end of one second, and we may find the velocity generated at the end of any given time by the formula $S \propto v$.

But when different bodies move with unequal accelerative forces; then, because the spaces described and the velocities generated are directly proportional to the forces, and inversely proportional to the masses or weights of the bodies; the spaces and velocities due to given times may be found by the formula $S \propto \frac{f.t^2}{m}$, and $v \propto \frac{f.t.}{m}$

If a body in motion be retarded by a constant force, the space described before the motion is extinguished will evidently be equal to that described by a body, moving from a state of rest, by an accelerative force, till it acquires a velocity equal to that with which the retarded body began its motion. Therefore, in retarded motions, the space described by a body before motion is destroyed, is proportional to the square of the initial velocity. But when there are different bodies subject to different retarding forces, the spaces described must be inversely proportional to the forces, and directly proportional to the masses or weights of the bodies. Therefore, the space described before motion is extinguished may be found by the formula $S \propto \frac{m. v^2}{f}$. And the time in which the motion is extinguished may be found from the formula $t \propto \surd S$.

Hence may be found, both the spaces described, and the velocities lost in given times, when a moving body is subject to a retarding force.

ORPIMENT.—*Composition.*

Orpiment is of a bright lemon, or golden color. It is soluble in boiling water, insoluble in acids. It is massive and lamellar, and burns with a pale blue flame.

OSCILLATION.—*Gravity,—Pendulum.*

If a body, or system of bodies vibrate about an axis of suspension, with a certain angular velocity by the action of gravity, then that point in the axis of the body or system in which a particle being suspended from the axis of motion will vibrate with the same angular velocity, is called the centre of oscillation of the body or system.

To determine this point, imagine the line joining the centres of suspension and oscillation to be oblique to the vertical position;—then the force of gravity upon any particle or body in the system, to turn it about the point of suspension, which is equal to the mass of the particle multiplied into the distance of the point of suspension from a vertical line passing through the particle, may be found, and, consequently, the sum of the actions of gravity upon all the particles or bodies. Also, let the force of gravity upon a particle in the centre of oscillation be found in the same way.

Next, the momentum with which any particle or body of the system, in vibrating, resists the action of gravity may be found, since it is equal to the mass of the particle or body, multiplied into the square of its distance from the centre of suspension, and the sum of all such moments may consequently be obtained; also, the momentum with which a particle placed at the centre of oscillation resists the action of gravity.

Then, in order that the angular velocities of the vibrating system, and of the particle in the centre of oscillation may be equal, the ratios of the actions of gravity to the resistance, must be the same in both cases; and by making a proportion of the four terms, the unknown quantity, which is the distance of the centre of oscillation from the point of suspension, may be found. The result is, that the place of the centre of oscillation in any body is coincident with the centre of percussion, except in certain cases of rare occurrence.

If the centre of oscillation in any vibrating body be made the point of suspension, that which was before the point of suspension becomes now the centre of oscillation.

In a right line or slender rod suspended from one of its extremities, the distance of the centre of oscillation, or of percussion from the point of suspension, is equal to ⅔ of the length of the rod,—in an isosceles triangle vibrating about a line parallel to its base, and passing through its vertex, it is equal to ¾ of the length of a perpendicular let fall from the vertex upon the base, —in a slender pyramid or cone suspended from its vertex, it is equal to ⅘ of the perpendicular height,—and in a circle attached by a slender rod or string to the point of suspension, and vibrating in its own plane, the distance of the centre of oscillation from the point of suspension, is equal to the sum of the distance from the point of suspension to the centre of the circle, and of the quotient arising from the square of the radius divided by twice that distance.

It has been proved, that the distance of the centre of gravity from the centre of oscillation, or percussion, is inversely proportional to the distance of the centre of gravity from the point of suspension. Therefore, knowing the positions of the centre of gravity and oscillation in any vibrating body, (as a right line), and having found the centre of gravity of any given body, mechanically or otherwise, the centre of oscillation, or percussion of this latter body can be found by simple proportion. Or, find a simple pendulum which shall perform its vibrations in the same time that the given pendulous body performs its vibrations; the length of the simple pendulum is equal to the required distance of the centre of oscillation from the point of suspension. Or, lastly, the place of the centre of oscillation may be found by the law of the vibration of pendulums, taking for datum that a simple pendulum 39⅛ inches long performs one vibration in a second time.

PACE.—*Measure,—League.*

The pace, as a measure is of no determinate length, though most military writers employ it as a scale of comparison. In France and England it is considered equal to two feet six inches, and seventy paces of a horse are considered equal to one hundred common paces. In Germany and among most of the northern powers, it is considered to be equal to two-tenths of a Rhinland Rood, or 2·4792 English feet.

PARK.—*Camp*,—*Reconnoitering*.

Artillery should always, if possible, be parked in situations in which it is not likely to interrupt the communications of the other troops. The form of the park must depend upon its situation; ten feet, in front, are usually allowed for each carriage and its interval, and about fifty feet in depth, from the axle-tree of the gun limber to that of the body of the ammunition waggon. The distance, however, between the line of guns, and that of their waggons must depend upon the number of horses attached to each carriage, and should allow sufficient space for putting them to, and at the same time for a free passage along the front. In parks, not on immediate service, it is customary to arrange the guns with their muzzles to the front; but if the guns are likely to be wanted at a short notice, appearances must not be studied, and the carriages should be parked with their shafts to the front, ready to receive the horses to them.

The quarter guard is posted in front of the park, and the non-commissioned officers' and gunners' tents on the flanks, at about twenty paces distance: at forty paces, to the rear, the subalterns', and at ten more the captains' tents are pitched. The tent of the commanding officer is pitched at twenty paces in rear of the captains', and the mess tent, at fifteen paces in rear of the commanding officer's. At a convenient distance in rear of the whole, the horses are picketed, in one or more lines, with the drivers on their flanks.

If the depth of the ground, or other circumstances, will not admit of this arrangement, the horses should be picketed in lines perpendicular to the front between the non-commissioned officers' and gunners' tents, and the carriages.

Pendulum.—*Gravity*,—*Gunnery*,—*Motion.*

Pendulums are applied to a variety of purposes. In the practice of gunnery, to ascertain the time of flight, the requisite length of fuze and the extent of the range, or distance of a hostile battery. Robins employed it to determine the velocity of a shot's motion in the atmosphere, and Moore to determine the strength of rocket composition.

On the Vibration of Pendulums.

It is proved by dynamics, that a body, descending down an inclined plane by the force of gravity, acquires the same velocity as by descending vertically down a space equal to the height of the plane; and the same is proved of a body descending down any system of inclined planes, or down the concave surface of any arc of a curve. And the motion of a pendulous body about its point of suspension being identical with that of a body rolling down the concave side of a circular arc, the radius of which is equal to the distance of the pendulous body from the point of suspension, it follows that such a body will acquire the same velocity, in the lowest point of the curve it describes, that it would have acquired by falling vertically through a space equal to the versed sine of half the arc of vibration.

If, therefore, two pendulums describe equal angular spaces about the point of suspension, their velocities, in the lowest point of the arcs they describe, will, by the laws of accelerated rectilinear motion, be proportional to the square roots of the versed sines of the arcs. Or, the arcs being similar, the versed sines are proportional to the arcs or to their radii. Therefore, the velocities of the pendulous bodies, in the lowest points of the curves, are proportional to the square roots of the lengths of the pendulums. Or the velocity acquired by descending down a vertical line, being proportional to the time of descent, the time of a vibration will be proportional to the square root of the length of the pendulum, or the lengths of pendulums are proportional to the squares of the times of vibration.

The length of a pendulum is to be estimated by the distance of its centre of oscillation from the point of suspension.

The experiments of Captain Sabine exhibit the following as the length of the pendulum vibrating seconds at each of the undermentioned places and latitudes.

At the Equator..	0°	0′		39·01520	Inches.
Trinidad	10°	38′	North	39·02211	do.
Jamaica	17°	56′	do.	39·03440	do
New York....	40°	42′	do.	39·10133	do.
London	51°	31′	do.	39·13926	do.
Unst........	60°	45′	do.	39·16934	do.
Hammerfest..	70°	4′	do.	39·19546	do.
Spitzbergen ..	79°	50′	do.	39·21134	do.

On the Ballistic Pendulum.

The ballistic pendulum is a block of wood attached to one extremity of a rigid bar, and capable of vibrating about a horizontal axis at the other extremity. A spear projects downwards from the lowest part of the block, and moves, during the vibration, in a groove formed in a circular arc, the centre of which is in the axis of vibration. This groove is filled with a composition of wax and soap; and a mark, made by the extremity of the spear on the surface of the composition, shews the extent of the vibration.

The block being made to vibrate by the impact of a shot discharged against it, the velocity with which the shot strikes the block may be determined in the following manner.

Let the centres of gravity, oscillation, and gyration of the pendulum be found; and, by the rules of dynamics, reduce the mass or weight of the pendulum to that which, if it were collected in the point of impact of the shot, would receive the same angular velocity from the force of impact which the given pendulum would receive, if its mass were accumulated in the centre of gyration. Then, because the shot is supposed to remain in the block after impact, the mass of the former is to be added to this reduced mass of the pendulum, in order to express the whole mass moved by the impact of the shot. Now the momentum of the shot is equal to its mass, or weight, multiplied by the velocity it obtains from the force of the powder. Therefore, by the laws of the collision of non-elastic bodies, the momentum of the shot, divided by the whole mass moved, gives an expression for the velocity of the block after impact, estimated at the point where the shot strikes it.

But, from the arc described by the point of the spear, the corresponding arc, described by the centre of oscillation of the block and ball together, may be found. And, by the laws of vibrations of simple pendulums, we can, from thence, find the velocity of the centre of oscillation at the lowest point of the arc; and, from that, by proportion, the velocity of the point of impact, at the moment the block was struck by the shot. This is equal to the former expression for its velocity; and, from the equation thence arising, we obtain the unknown quantity, which is the velocity of the ball.

With the same pendulum, and the same weight of ball, the velocity of the latter is directly proportional to the versed sine, or to the chord of the arc described by the centre of oscillation of the pendulum.

The ballistic pendulum is also employed to ascertain the strength of the composition of a rocket, by attaching the latter to the face of the pendulum, perpendicularly to the vertical axis, and in the plane of motion; and observing the angle which the axis of the pendulum makes with a vertical line at the instant the rocket ceases to burn.

PENETRATION.—*Charge,—Fortification.*

If a shot be discharged against any material, such as timber or earth, it will penetrate to a certain depth before the resistance of the material stops its motion; and, from the theory of forces, Dr. Hutton gives the following equation between the resisting force of the material, the velocity of the shot, and the depth penetrated;—$f = \frac{v^2}{4gs}$; where f = the resisting force, s = the penetration, in feet, and $g = 16$ feet; and, from a mean of several experiments on the resistance of elm timber, he makes $f = 17{,}000$ times the force of gravity, for that material. Dr. Hutton also shews that oak resists more than elm, in the ratio of 19 to 17, or that for oak, $f = 19{,}000$ and that elm resists more than earth, in the ratio of 7½ to 1, or that, for earth, $f = 2320$ nearly. Again he shews that the depth of penetration is proportional to $\frac{d.D.v^2}{f}$ where d = density of the ball, D = its diameter, v = the velocity of the shot, and f = the force of resistance.

To produce the greatest damage to any splintering object, as oak, by a shot fired against it, the shot fired should lose all motion just as it ceases to be resisted by the object, which happens when the shot has forced its first hemisphere out of the further surface of the object. And the charge necessary to produce the greatest effect when a shot is fired against such object, the side of a ship, for example, may be found by the formula, $C = \cdot 045 \frac{S \cdot W}{D}$; where $C =$ the charge, $W =$ the weight of the ball, both in pounds, $S =$ the thickness of the side of the ship, and $D =$ the diameter of the shot, both in the same denomination.

If the shot is required to pierce both sides of the ship, and the greatest damage is to take place on the farthest side, make S, in the above equation, equal to double the thickness of the side, and find the charge accordingly. This, Mr. Moore thinks, would be the most advantageous practice, on account of the chance of the ball striking the mast of the ship.

Mr. Moore, from data afforded by experiment, obtains the following formula to determine the charge necessary to enable a shot of given weight and diameter just to penetrate through a bank of dry earth, the thickness of which is also given, $C = \cdot 01012 \frac{S \,.\, W}{D}$; where $S =$ the thickness of the bank, and $D =$ the diameter of the shot, both in the same denomination; $C =$ the charge, and $W =$ the weight of the ball, which will also be both of the same denomination.

PERCUSSION.—*Pendulum,—Oscillation.*

If a body or system of bodies either vibrate or revolve about an axis or point of suspension, and meet an immoveable object in a point so situated that, after impact, the body or system becomes quiescent, or has no tendency to turn about the point of impact, that point is the centre of percussion. The determination of this point depends on the sum of the momenta of all the points above it, being equal to the sum of all below it. Imagine a line to be drawn from the point of suspension, through the centre of percussion, then the momentum of one of the points or bodies will be expressed by its mass multiplied into its distance from the point of suspension, and its momentary effect will be in the direction of a tangent to the circle it describes about the point of suspension. This momentum being estimated by the resolution of forces, in a direction perpendicular to the line joining the points of suspension and percussion, and multiplied into the distance of its point of application from the latter (which point of application is where the tangent meets the said line), will express the effect to turn the system about the centre of percussion. In the same manner the actions of all the other points or bodies in the system may be found; and, as the whole system is to be quiescent after impact, the sum of all these actions must be made equal to zero. And, from the equation thence resulting, the unknown quantity, which is the distance from the point of suspension, to that of percussion, may be found.

Petard,—*Artillery*,—*Breach*.

In 1826, an experiment was made at Woolwich with a Petard charged with nine pounds, and a Leathern Bag, containing fifty pounds of powder, to ascertain their relative values in forcing open gates and barriers. The fixing of the Petard occupied six men nearly twenty minutes, and, when exploded, entirely failed in forcing open the gates. The Leathern Bag was fixed by two men in five minutes, and forced the gates completely open.

PLATFORMS,—*Battery,—Fortification.*

Weight, Dimensions, etc., of Oak Platforms.

ORDNANCE, ETC.					Pieces. No.	Dimensions. Length.	Breadth.	Thickness.	Weight. Cwt.
GUNS.									
Sleepers					5	14·000	·500	·500	9·00
Hurters					1	8·000	·834	·834	2·75
Planks					14	11·000	1·000	·208	17·00
Weight					..	..	..	..	28·75
GUNS AND HOWITZERS.									
Madras.	Original.		Traversing Brace		1	7·250	·985	·312	1·00
			Sleepers	Front	1	7·583	·750	·625	1·75
				Centre	1	8·875	·750	·625	2·25
				Rear	1	11·083	·750	·667	3·50
			Planks	Right	1	17·500	·985	·313	2·50
				Centre	1	18·750	·985	·313	2·50
				Left	1	17·500	·985	·313	2·50
			Weight		..	..	..	..	16·000
	Modified.	Garrison.	Planks		2	18·000	1·000	·250	4·50
			Sleepers	Front	1	7·000	·750	·750	1·75
				Centre	1	8·167	·750	·750	2·25
				Rear	1	10·000	·834	·750	2·75
			Traverse Boards		1	5·834	·750	·250	·50
			Weight		..	..	..	..	11·75
		Siege.	Planks		2	17·500	1·000	·250	4·25
			Sleepers	Front	1	7·000	·750	·750	1·75
				Centre	1	8·167	·750	·750	2·25
				Rear	1	10·000	·834	·750	2·75
			Trail	Plank	1	18·000	1·000	·250	2·25
				Block	1	3·000	·583	·834	1·00
			Weight		..	..	..	..	14·25
MORTARS.									
Planks					13	13·500	·834	·208	16·00
Sleepers					5	9·250	·667	·667	10·75
Weight					..	..	..	..	26·75

PONTOONS,—*Barrel*,—*Bridge*,—*Cordage*.

Weight, Dimensions, etc. of Flat Bottomed and Cylindrical Pontoons, with their Apparatus.

PONTOONS, ETC.	Pieces.	Dimensions.			Weight.
	No.	Length.	Breadth.	Thickness.	Cwt.
FLAT BOTTOMED.					
Pontoons	1	21·500	4·750	2·250	9·465
Anchors	1	..	..	..	·466
Grapplings	1	..	..	..	·388
Buoys	1	..	..	..	·116
Oars	2	14·000	..	..	·196
Boat-hooks	1	14·000	..	..	·107
Setting Poles	1	14·060	..	..	·120
Coupling Bolts	6	..	..	..	·116
Blocks (8-inch)	2	..	..	..	·129
Park Pickets	2	..	..	..	·223
Cable (3-inch)		516·000	..	..	1·286
Lashings (2-inch)		75·000	..	..	·196
(1½ „)		225·000	..	..	·120
Baulks	6	22·667	·375	·375	4·285
Chesses	8	11·500	2·334	·125	9·143
Gangboards	1	22·000	1·000	·187	1·160
Carriages	1	..	..	..	12·282
Weight	..	..	..	..	39·738
CYLINDRICAL.					
Pontoons	2	22·750	2·667	2·667	8·143
Anchors	1	..	..	..	·590
Oars	7	14·000	..	..	·630
Rowlock Lashings (1-inch)	4	3·750	..	..	·009
Boat-hooks	1	14·030	..	..	·049
Cable (3-inch)		180·000	..	..	·562
Saddles	2	12·000	1·167	·271	1·790
Saddle Lashings (1-inch)	4	15·000	..	..	·032
Baulks	12	15·000	·375	·250	5·267
Baulk Lashings (1-inch)	4	22·500	..	..	·045
Chesses, Whole	8	11·458	2·083	·125	7·196
Half	4	11·458	1·042	·125	1·799
Side Lashings (1½-inch)	2	2·000	..	..	·006
Carriages	1	..	..	..	18·742
Weight	..	..	..	..	39·969

On the Buoyancy of Pontoons.

If a body float in a fluid, it displaces just as much of the fluid, as is equal in weight to the weight of the body. Hence, if the weight of a body immersed, or partly immersed in a fluid, be deducted from the weight of the fluid displaced, the remainder will evidently be the buoyancy of that particular body, or, the greatest weight that it will sustain without sinking.

1. *Given the Bulk of Water displaced by a Pontoon to find its Weight.*

Multiply the bulk of water displaced, in cubic feet, by its specific gravity, and the product will be the weight of the pontoon, in ounces.

The quantity of water displaced by a pontoon being 16·96 cubic feet, required its weight?

Here, $(16{\cdot}96 \times 1000) \div 16 = 1060$ lbs.

2. *Given the Weight and Dimensions of a Pontoon to find its Buoyancy.*

Multiply the content or bulk of the pontoon in cubic feet, by the specific gravity of water, and that product, minus the weight of the pontoon, will be the buoyancy required, in ounces.

The breadth and depth of a pontoon being respectively 4·75, and 2·25 feet, its length at top 21·5, and at bottom 17·167 feet, and its weight 1060 lbs., required the greatest weight that it will support without sinking?

Here, $\Big((206{\cdot}6268 \times 1000) \div 16\Big) - 1060 = 11{,}854{\cdot}175$ lbs.

Experience teaches that, with open boats, the highest water-line should be fixed at least 9 inches beneath their gunwales. Required therefore under these circumstances, the greatest load that a boat of the above description will support, its own weight included?

Here, $(132{\cdot}58912 \times 1000) \div 16 = 8286{\cdot}82$ lbs.

PORTFIRES.—*Composition.*

In driving portfires, four drifts are required, each ·425 of an inch in diameter, and 17·8; 12·6; 7·5, and 4·2 inches respectively in length. The mallet should weigh about 1 pound 10 ounces, and the ladle should contain 1 drachm of composition.

Implements required,—

Mixing Tables.
Hair Sieves.
Rolling Tables.
„ Boards.
Formers.
Guages.
Knives.
Composition Boxes.
Moulds.
Mallets.
Drifts.
Ladles.
Slices.
Scissors.

The paper for the cases is cut into rectangles each nineteen inches long, by about ten and a half broad, according to its quality. Each portfire, when completed is sixteen inches and a quarter in length, and usually burns from twelve to fifteen minutes.

Blasting portfires are made 2 feet long on a former tapering from ·3 to ·2 of an inch, in diameter, and are filled with the following composition,—

Mealed Powder..........	8 lbs.
Pulverized Saltpetre......	7 „
Coarse Sulphur..........	2 „

These ingredients must be thoroughly incorporated and carefully rammed—not driven—into the cases, or the portfire will explode on being fired, and endanger the life of the man by whom the match is applied. The object of making the cases of these portfires smaller at one end than at the other, is that, should the shaft of the mine exceed two feet in depth, the length of the train may be extended in the same proportion by joining two or more of them together.

Materials required to complete 500 of each of the undermentioned Portfires.

MATERIALS.		Portfires.		
		Long.	Blue.	Miners.
Paper, Portfire	Quires	22·083	..	..
Brown	,,	2·208	..	2·083
White	,,	..	..	35·000
Sugar Loaf Blue	,,	..	41·667	..
Saltpetre	lbs.	84·000	7·500	25·000
Sulphur	,,	28·000	..	25·000
Gunpowder	,,	15·500	..	50·000
Packthread	,,	·500	·937	..
Twine	,,	..	..	·078
Flour	,,	5·625	·125	2·500
Copperas	,,	·125	..	..
Paint, Lampblack	,,	·016	..	..
White Lead	,,	6·000	..	..
Raw Linseed Oil	Pints	1·500	..	..
Alcohol	,,	·375	..	..

Proof.—*Charge,—Dispart,—Gun,—Carronade.*

Ordnance of every description undergoes various kinds of proof before it is received into Her Majesty's service. Each gun, howitzer, mortar, and carronade is guaged to ascertain the accuracy of its several dimensions, internal and external, the coincidence of the axes of the bore and metal, and the position of its chamber, vent, and trunnions. It is then fired with an established charge, a given number of times, and searched after each round as to the effect of the firing. Endeavours are next made, by means of an engine, to force water through any flaws or crevises that may exist in the bore, and finally, it is examined internally by light reflected from a mirror.

In iron guns, a variation in the prescribed length exceeding ·3 of an inch, condemns them. If the diameter of the bore of an 18-pounder, or of any iron gun of a higher calibre, vary ·033 of an inch from its prescribed dimensions, or if the axis of the bore of such a gun deviate from its true position more than ·25 of an inch, it is condemned. In like manner, if any other iron gun vary in the diameter of its bore ·025 of an inch from its true dimensions, or if the axis of its bore deviate more than ·334 of an inch from its true position, it is rejected. If a brass gun vary in the diameter of its bore more than ·025 of an inch from its true calibre, or deviate in any other respect more than ·2 of an inch from its true dimensions, it is condemned. Every description of iron guns, is fired twice with the established charge, one shot, and two high junk wads. Brass guns, from a 12 to a heavy 6-pounder are also fired twice, and the others three times. If, after any of these firings, a cavity or hole ·2 of an inch in depth, be discovered in the bore of an iron gun, behind the first reinforce ring or ·25 of an inch in depth, in front of that ring, or if, in the bore of a brass gun, a cavity or hole be discovered ·15 of an inch in depth upwards or sideways, or ·1 of an inch in depth downwards, between the breech and first reinforce ring, or ·2 of an inch in depth upwards or sideways, or ·15 of an inch in depth downwards in front of that ring, the gun is condemned.

Mortars and howitzers must in no respect deviate externally from their true dimensions more than ·1 of an inch in the 10 and 8-inch howitzers, nor more than ·05 of an inch in the 24 and 12-pounder howitzers, and the 5½ and 4⅖ inch mortars. The bores and chambers of mortars and howitzers must, in no case, deviate more than ·025 of an inch from their true diameters and positions.

Brass mortars and howitzers are fired twice with an iron shell, and the chamber full of powder,—the mortars on their beds, at an elevation of about 75 degrees,—the howitzers on their carriages at about 12 degrees elevation. Iron mortars are proved with the chamber full of powder, and an iron shot equal in diameter to the diameter of their respective shells.

If after either of these firings, a cavity or hole ·1 of an inch in depth, be discovered in the chamber, or ·15 of an inch in depth in the chase of a brass mortar or howitzer, it is rejected, and a cavity or hole ·15 of an inch in depth in the chamber, or ·2 of an inch in the chase of a 10 or 8-inch howitzer, is sufficient to condemn it.

The bores and chambers of carronades must not deviate more than ·05 of an inch from their true dimensions and positions. Carronades are fired twice with one shot and wad, and if a cavity or hole ·2 of an inch in depth in the bore, or ·1 of an inch in depth in the chamber be discovered, they are condemned.

Having undergone these several proofs, and the subsequent searchings, each gun, howitzer, and carronade is separately subjected to the water proof. The hose of the engine is, for this purpose, fitted and secured to its muzzle, the vent being at the same time hermetically sealed by a plug, and two or three efforts are made to force the water through the metal. It is then left to dry, and shortly afterwards, generally the next day, examined by the mirror. Should there be any flaws or crevises in the bore which may have escaped discovery by the former proofs, their existence will be readily detected by this, as the water will continue to weep or flow from defects of this description long after the solid parts of the bore become perfectly dry.

If a gun, mortar, howitzer, or carronade, be condemned as unserviceable on any of the foregoing grounds, it is marked with a cross, to which one of the letters, *D*, *S*, or *W*, is annexed,—the letter *D* signifying that it is defective in its dimensions,—*S*, that its defects have been discovered by the searcher, —*W*, that they were discovered by the forcing engine.

RECONNOITERING.—*Artillery*,—*Bridge*,—*Measure*.

Reconnaissances are either general or special. General, when the object is to acquire, usually by a studious and careful examination of the map, a comprehensive knowledge of the country in which the army is to operate. Special, when the information required is of a more detailed description, or has reference to a particular district or operation,—information which can be acquired only by a minute personal examination of the ground itself.

It seldom happens that the information afforded by the ordinary map of a country, how accurate soever it may be in other respects, is other than of the most general description. The more prominent features of the ground, its natural and political divisions, the relative positions of the towns and larger villages, the directions of the main roads, and the courses of the rivers and more considerable streams, are alone delineated on such a map, and usually comprise the whole of the information to be acquired by its study. Hence the necessity of a special reconnaissance or examination of each of the several districts into which the country is divided, as the only means of supplying the deficiencies of such a map, or of acquiring fuller and more detailed information, on such of the following points as may be applicable in each particular case.

1. Description of the Ground, its Cultivation, and Produce.

What parts of the ground are mountainous or hilly, and what level. Whether the hills are steep, broken by rocks, or whether they rise by gradual and easy slopes, or if the ground is undulated in gentle swells. Whether the connexion of the high ground is obvious and continued, or if the heights appear detached from each other. In what directions the ridges run, and which is their steepest side. The nature and extent of the valleys, and of the ravines, where they originate, in what direction they run, and whether they are difficult of access or to be easily passed.

Whether the country is barren or cultivated, and the kind of cultivation, whether vines, olives, or corn; and if the latter, what descriptions of it are growing and in what part is it most abundant. If it be a country of pasturage, whether it is pastured by cattle, sheep, or horses, and in what numbers. What parts of the country are open, and what enclosed. Whether the enclosures are small or extensive, and whether formed by stone walls, ditches, hedges, or fences of any other kind. What parts are wooded, and whether with grown timber, or coppice, and with what species of trees. The nature of the soil, and of the country generally with reference to the operations of the troops,—distinguishing those parts which are favorable for the acting of cavalry and artillery from those for infantry only.

2. Rivers, Canals, Bridges, and Ferries.

The sources of the rivers, and the direction of their currents, whether they are rapid or otherwise; their breadth and depth, and to what variations they are subject, at the different seasons of the year; the nature of their channels and banks, whether rocky, gravelly, sandy, or muddy; of easy or of difficult access. Whether they are navigable, from and to what points, and by what description of vessels or boats. The bridges across them, whether of stone or wood, their length and breadth, and whether accessible to artillery, and capable of supporting its weight. The fords, with similar remarks, and whether they are always passable, or only at certain times and seasons. The breadth of the ferries, and the nature of the landing places on each side; what description of boats are used upon them; how many men, horses, or carriages each boat is capable of passing over at each crossing; what time the passage occupies, and in what manner it is performed.

The course, breadth and depth of canals, the nature of the traffic carried on upon them, the number of boats usually to be found at the different stations. The nature, dimensions, and buoyancy of the boats, and whether they are tracked by men or horses, or how otherwise navigated.

The situation, extent, and boundaries of lakes, or inlets of the sea, what description of vessels can navigate them, with such of the above observations as are applicable to them. The situation and extent of marshes, whether they are passable for troops in any part, and whether they continue throughout the year, or exist only in the wet season.

3. Towns and Villages, Population, Churches, and Convents.

The size of the towns and villages, and the number of their inhabitants, whether they are well supplied with provisions or not. The number of houses, churches, convents, or other public buildings. Whether the houses are commodious, or small and mean. What number of troops could be accommodated in the private houses, and what in the public buildings. What stabling, or other covering there is for horses, whether the town is open, or walled, and favourably situated for defence or otherwise. If it is capable of being strengthened, and by what means, with similar observations in regard to convents, gentlemen's seats farms, or other detached buildings. Plans or sketches of walled towns, defensible villages, and detached buildings should always accompany the reports upon them. The number of carriages, horses, mules, and draught oxen, in the possession of each farm or village, should be stated, together with the general means of conveyance made use of in the country. Whether the place is unhealthy, or not; if it is, whether there is any obvious local cause, and whether it is in general unhealthy, or only so at particular seasons.

4. Roads, Bridges, Ferries, and Fords.

The general nature of each road, as also all the variations which occur in it from distance to distance should be accurately described. Whether the road has been regularly made, or appears to have been formed only by the use of the people of the country. Whether it is fit for artillery, or practicable for any other description of wheel carriages, for cavalry, or for infantry only, over what description of soil it passes, whether rocky, gravely, sandy, clayey, or earthy, and to what injuries it is liable in bad weather. Whether it is easily reparable or not, what kind of materials are required for that purpose, and whether they are to be found in the vicinity. Whether bad parts of the road, or narrow and embarrassed streets, if any of the towns and villages through which it passes can be avoided by going out of it for a short distance. Whether any great improvement can be made in the general direction of the road by adopting a new line altogether for a considerable distance, and what work is necessary in either of these cases. Particular attention should be paid to the different ascents and descents of the road, whether they are gradual and easy, or abrupt, rugged, and stony, having short turns, or other difficulties. Whether the road is wide enough in those parts which run along the sides of hills, and whether it is even, or canted off the level, so as to be unsafe for carriages. In those parts where the road passes between walls, or where it forms a hollow way between banks of earth, rocks, or other obstacles, its breadth ought to be measured, and it should be stated whether it can be widened or the obstacles removed which confine it.

The ferries, bridges, and fords met with upon the road should be particularly described. The possibility of obstructing, or breaking up the road so as to prevent its being used by the enemy, or of destroying the bridges and fords upon it should also be stated, and the means of obtaining these objects should be pointed out, as likewise the time and labour requisite for such a work. The distances of the places along the road from each other should be given both in the measures of the country, and in English miles, averaged as accurately as possible. The time required to travel the different distances, at the ordinary walk of a horse, or of a man should also be stated, the names of the places to the right and left near the road, and at what points the communications strike off, with the distance of each place from the main road. Care must be taken that the names of the towns, villages, rivers, and all other objects be spelt in the same manner as by the natives of the country, and when the spelling and pronunciation differ very much, the names should also be written (in parenthesis) as they are pronounced.

5. Camps, Passes, Posts, and Positions.

Every strong pass, post, or more extensive position which presents itself either upon a line of road, or in any other situation, as also all passes favorable for encamping or bivuacing troops either with a view to a position, or to convenience upon a march, should be particularly described. Their situation, extent, facility of access, nature of the soil, supply of water at all seasons, quantity and kinds of wood, whether in sufficient abundance for hutting the troops, or only for furnishing fuel. A sketch of the ground, upon a pretty large scale should always accompany these reports.

Advantage should be taken of every opportunity that presents itself to verify and extend all such information as may be obtained upon the points abovementioned, and whatever new information may be acquired, should, without loss of time, be reduced to writing, and put into such a shape that it may be ready the instant it is called for.

Sketches of positions should never be made on a less scale than four inches to an English mile; more general sketches may be made up on a scale of two inches to a mile, and tracings of roads upon a scale of one inch to a mile.

In all reports, care should be taken to state distinctly what parts of the information they contain has been acquired by personal examination of the objects to which they relate, and what upon the authority of others; and, in this latter case, the source of the information should be mentioned that an opinion may be formed of the degree of credit to which it is entitled.

Resins.—*Composition.*

Resins are vegetable substances, solid and brittle, with a slight scent and taste. They are non-conductors of electricity, and, in their natural state, not chrystillizable; soluble in alcohol, insoluble in water. Inflammable, burning with much smoke, and, on that account, *employed* in laboratory compositions.

Ricochet.—*Battery*,—*Gunnery*.

Ricochet Practice, with *Guns*, *Howitzers*, and *Carronades*.

ORDNANCE.	Ranges.								
	400 (Yards.)			600 (Yards.)			800 (Yards.)		
	Elevation	Charge	Flight	Elevation	Charge	Flight	Elevation	Charge	Flight
Guns.									
24-Pounder..*Siege*	11·00	·500	..	9·50	·750	..	8·50	1·000	..
	7·75	·625	..	6·50	1·000	..	6·50	1·250	..
	6·25	·750	..	4 75	1·250	..	5·50	1·500	..
							3·75	2·000	..
18-Pounder..*Siege*				7·25	·750	..	7·00	1·000	..
				5·00	1·000	..	4·25	1·500	..
12-Pounder..*Siege*	6·50	·375	..	7·75	·500	..	6·50	·750	..
	4·50	·500	..	6·00	·625	..	4·50	1·000	..
				4·75	·750	..			
9-Pounder..*Field*				7·50	·375	..			
Howitzers.									
10-Inch ......*Siege*	8·50	2·000		9·75	2·500	4·50	7·50	3·500	5·00
	6·25	2·500		7·25	3·000	4 00	6·25	4·000	4·50
				6·50	3·500	3·75			
				5·00	4·000	3 50			
8-Inch ......*Siege*	9·50	1·000	3·50	10·00	1·250		8 50	2·000	5·00
	6·00	1·500	3·25	9·00	1·500	4·50	6·25	2·500	4·50
				6·25	2·000	3·75			
				5·50	3·500	3·25			
24-Pounder..*Field*	7·50	·375	3·50	5·25	·750	3·75			
				6·50	·750	..			
				4·75	1·000	..			
12-Pounder..*Field*				8·00	·375	4·00			
				6·50	·500	3·75			
				5·75	·750	..			
Carronades.									
68-Pounder........				8·25	1·500	4·25			
				6·25	2·000	..			

OBSERVATIONS ON RICOCHET FIRING.

Ricochet firing is not restricted to any particular species or nature of ordnance, neither is it restricted to a particular charge or elevation. The charge and elevation vary with the range, the position, and elasticity of the reflecting plane, or plane on which it is intended the shot shall first impinge, the difference of level of the battery and hostile object, and the distance in rear of that object at which it is desired the shot shall be delivered.

In the field, or in firing at an enemy's troops the charge is usually regarded as a fixed quantity,—the elevation alone being varied. With guns, this variation seldom exceeds three degrees,—with howitzers, the initial velocity of the projectile being considerably less, the elevation is not restricted to that limit. If a shot be fired, with the service charge, under a greater angle than three or four degrees, and the ground on which it is to ricochet be of more than ordinary tenacity, it will be apt to bound over the heads of the troops or other object fired at, and thus effectually defeat its intended purpose. It is also to be observed, that the less the elevation of the gun, and consequently the smaller the angle under which a shot is delivered or made to ricochet, the longer will it preserve its force, and have effect.

In the ricochet of an enemy's work, the charge and elevation must be such that the shot, when it has passed the crest of the hostile parapet, shall have described a considerable portion of the descending branch of its trajectory, and if the work and battery be on the same level or nearly so, the angle of elevation or projection should not exceed nine degrees. If, on the contrary, the position of the work be consiably elevated above that of the battery, and the elevation of the gun be unchanged, then the initial velocity of the projectile must be small in proportion, otherwise it will still be in the ascending branch of its trajectory after it has passed over the hostile object. In either case, both the elevation and charge must be so regulated that the shot shall be delivered under a very acute angle on the terreplein of the work, as close as possible to the foot of the interior slope of the defilading parapet, and with sufficient force to overthrow every thing it may encounter in its progress along the ramparts.

It would appear, from a series of practice carried on at Woolwich in 1821 with various kinds of ordnance —of which the preceding table is an abstract—against a work on nearly the same level as the battery, that, with heavy ordnance two-thirds of the shot fired took effect on the work at a range of four hundred yards, while at a range of six hundred yards, only from two to three-fifths took effect; and that, at a range of eight hundred yards, three-fifths of the ammunition expended was uselessly thrown away. It also appears, that of one hundred and seventy shells fired, fifty took effect, though only thirty-three of that number burst in the work, in consequence of the fuzes having been cut longer than usual, that the shells might lodge in the traverses previous to their exploding.

Hence ricochet batteries, to be effective, should, if possible, be established at a distance of four hundred, and not exceeding six hundred yards, from the place against which they are to act, and that greater accuracy in cutting the fuzes is advisable. It would also appear, from this practice, that the best angle under which to enfilade such a work, is somewhere between six and nine degrees measured above the crest of the parapet—Vide article Elevation—and consequently that the charge and initial velocity of the projectile, should be regulated in accordance with these practically-ascertained facts.

Rockets.—*Composition.*

General Table of Signal Rockets.

IMPLEMENTS, ETC.	Rockets. 2-Pound.	Rockets. 1-Pound.	Rockets. ½-Pound.
Cases, etc.			
Body,—			
Diameter, Exterior	·178	·141	·112
Interior	·128	·102	·080
Vent	·045	·035	·028
Length	1·331	1·056	·837
Heading,—			
Cylinder, Diameter	·237	·187	·149
Length	·355	·283	·224
Cone, Diameter	·237	·187	·149
Length	·355	·283	·224
Stick,—			
Length	10·334	8·167	6·500
Thickness, Large End	·094	·060	·042
Breadth ,, ,,	·084	·067	·058
Square, Small ,,	·044	·031	·021
Distance of the Poize from vertex of the cone	2·750	2·084	1·875
Implements, etc.			
Drifts,—			
Diameter	·127	·101	·079
Length 1 Hollow	1·335	1·084	·917
2 ,,	1·167	1·000	·834
3 ,,	·834	·834	·667
4 Solid	·584	·500	·417
Spindle,—			
Length	·621	·493	·381
Diameter, at the Point	·015	·012	·009
,, ,, Base	·045	·035	·028
Choke Guage, Length	·125	·104	·083
Ladle,—			
Length	·266	·211	·120
Diameter	·128	·101	·080
Content Drs.		5	4
Mallet, Nature Lbs.	7·250	3·500	2·083
Blows to each ladleful of composition	31	25	21

Rocket cases are prepared in three separate parts,—the body of the case, the cylinder, and the cone. In forming the body, the outside paper is cut into a right angled trapezoid, the inside ones into rectangles—the papers for the cylinders are also cut into rectangles, and those for the cones into sectors of circles. The base of the right-angled triangle forming the sloped side of the trapezoid is made equal, in length, to the circumference of the body of the case, and the arc of the sector, to that of the cylinder.

Each rocket is driven solid above the spindle to the extent of an external diameter of the case, and over that one-fifth of a diameter is driven with dry clay.

Implements required..

Mixing Tables.
Composition Boxes.
Hair Sieves.
Rolling Tables.
„ Boards.
Formers.
Gauges.
Nipples.
Cutters.
Knives.
Scissors.
Moulds.
Mallets.
Drifts.
Ladles.
Slices.

The heights to which rockets ascend, and the distances at which they may be seen on a clear night in a level country, vary in the direct ratio of their diameters. Rockets of between three and four inches in diameter ascend, according to Robins, to heights varying from 1000 to 1200 yards; while others, of between one and two inches in diameter ascend only from 450 to 600 yards. It appears also, from some experiments which he made "the better to determine the extent of country through which they could be seen," that they were visible at distances varying from thirty-five to forty miles, and that their times of ascent or flight varied from seven to ten seconds.

Materials required to complete 100 of each of the undermentioned Rockets.

MATERIALS.		ROCKETS.		
		2-Pound.	1-Pound.	½-Pound.
Paper, Rocket	Quires	12·500	6·000	3·334
Portfire	,,	1·834	·375	·167
White	,,	·500	·208	·208
Light Blue	,,	·167	·084	·084
Brown	,,	..	·125	·125
Flour	lbs.	3·500	3·000	2·000
Isinglass	,,	2·406	·491	·469
Glue	,,	·500	·016	·016
Saltpetre (Pulverized)	,,	160·000	50·000	30·000
Sulphur (Sublimed)	,,	39·000	12·250	7·500
Charcoal (Ground)	,,	24·000	12·000	6·750
Gunpowder (Mealed)	,,	17·500	2·625	1·750
Antimony	,,	21·000	4·250	3·000
White Copperas	,,	·062	·031	·031
Quilting Line, 6-Pounder	,,	2·000	..	..
3 ,,	,,	..	1·000	·438
Packthread	,,	4·000	1·750	1·250
Dutch Twine	,,	..	..	·063
Packing ,,	,,	·250	..	..
Paint, Prussian Blue	,,	·008	·008	·008
White Lead	,,	7·000	3·000	3·000
Raw Linseed Oil	Quarts	1·500	·750	·750
Alcohol	,,	6·000	1·375	·875
Vinegar	,,	11·000	2·250	1·500
Alder	Cubic Feet	1·000	·500	·250

The proportions of materials given above, the timber, usually pine or other soft wood, for the sticks not included, are the exact quantities required, no allowance being made for waste,—the calculation, as regards the paper, is made on the supposition that it will be provided of a fair average quality. It may therefore be necessary, on this item, to demand a further quantity, but in no case should this additional supply exceed one per cent. on the quantities given in the table.

ROPES.—*Cables,—Cordage,—Hawsers.*

Weight, Dimensions, etc. of Ropes.

MANUFACTURE, ETC *(Common* ***Mad***

FATHOMS.	1½-INCH. (21 Thds.)		2-INCH. (33 Thds.)		2¼-INCH. (51 Thds.)		3-INCH. (75 Thds	
	Weight.	Strength.	Weight.	Strength.	Weight.	Strength.	Weight.	Strength.
1	..	1,008	..	1,792	1	2,800	1	4,
2	..		1		2		3	
3	1		2		3		5	
4	1		2		4		6	
5	2		3		5		8	
6	2		4		6		10	
7	3		5		8		12	
8	3		5		9		13	
9	4		6		10		15	
10	4		7		11		17	
11	4		7		12		18	
12	5		8		13		20	
13	6		9		14		22	
14	7		9		15		23	
15	8		10		16		25	
20	9		14		23		34	
25	11		17		28		42	
30	14		22		34		51	
35	16		25		39		59	
40	19		29		46		68	
45	21		32		51		76	
50	23		37		57		85	
55	25		40		62		91	
60	28		44		69		102	
65	30		47		74		110	
70	33		52		80		119	
75	35		55		85		127	
80	38		59		92		136	
85	40		62		97		144	
90	42		67		104		153	
95	44		70		109		161	
100	47		74		115		170	
105	49		77		120		178	
110	51		80		125		186	
115	53		83		130		192	
120	56		86		135		200	
122	58		91		141		208	

Weight, Dimensions, etc. of Ropes—*continued.*

MANUFACTURE, ETC. *(Machine Made.)*

FATHOMS.	3½-INCH. (96 Thds.)		4-INCH. (132 Thds.)		4½-INCH. (168 Thds.)		5-INCH. (204 Thds.)	
	Weight.	Strength.	Weight.	Strength.	Weight.	Strength.	Weight.	Strength.
1	2	5,488	2	7,168	3	9,072	4	11,200
2	4		5		7		8	
3	6		8		10		13	
4	8		11		14		17	
5	10		14		18		21	
6	12		17		21		26	
7	14		19		25		30	
8	16		22		28		35	
9	18		25		32		39	
10	20		28		36		43	
11	22		30		39		47	
12	24		33		42		51	
13	26		36		46		56	
14	28		39		50		60	
15	30		42		54		64	
16	32		45		57		69	
17	34		47		61		74	
20	41		56		72		87	
25	51		70		90		108	
20	61		85		108		130	
25	71		99		126		151	
30	82		113		144		175	
45	92		127		162		196	
50	103		141		180		219	
55	113		155		198		240	
60	123		170		216		263	
65	133		184		234		284	
70	144		198		253		306	
75	154		212		271		327	
80	165		226		289		350	
85	175		240		307		371	
90	185		255		325		394	
95	195		269		343		415	
100	206		283		361		438	
105	216		297		379		459	
110	226		311		397		481	
115	236		325		415		502	
120	246		339		433		525	
122	252		346		441		535	

Weight, Dimensions, etc. of Ropes—*continued.*

Manufacture, etc. *(Machine Made.)*

Fathoms.	5½-Inch. (285 Thds.) Weight.	5½-Inch. (285 Thds.) Strength.	6-Inch. (300 Thds.) Weight.	6-Inch. (300 Thds.) Strength.	6½-Inch. (348 Thds.) Weight.	6½-Inch. (348 Thds.) Strength.	7-Inch. (403 Thds.) Weight.	7-Inch. (403 Thds.) Strength.
1	5	13,552	6	16,128	7	18,928	8	21,952
2	10		12		14		17	
3	16		19		22		26	
4	21		25		29		35	
5	27		32		37		43	
6	32		38		44		52	
7	37		45		52		61	
8	43		51		59		70	
9	48		58		67		79	
10	54		64		74		87	
11	59		70		81		95	
12	64		76		88		104	
13	70		83		96		113	
14	75		89		103		122	
15	81		96		111		130	
16	86		102		118		139	
17	91		109		126		148	
20	108		129		149		175	
25	135		161		186		218	
30	162		193		224		263	
35	189		225		261		306	
40	216		258		299		351	
45	243		290		336		394	
50	270		322		374		438	
55	297		354		411		481	
60	325		387		449		526	
65	352		419		486		569	
70	379		451		513		614	
75	406		483		550		657	
80	433		516		598		702	
85	460		548		635		745	
90	487		580		673		790	
95	514		612		710		833	
100	541		645		748		877	
105	569		677		785		920	
110	595		709		822		964	
115	622		741		859		1007	
120	649		774		897		1052	
122	661		787		913		1071	

SALTPETRE.—*Composition,—Gunpowder.*

A combination of nitric acid with a fixed alkali, known also as nitre, or nitrate of potash. It is an abundant natural product of the East Indies, whence that used in this country is procured. In France and Germany, it is produced artificially by lixiviating old plaster rubbish. It is also extracted from putrified animal and vegetable substances mixed with calcareous earths. Animal substances, without the addition of earth, are likewise said to yield saltpetre by putrefaction. The properties of this salt, when it is thoroughly purified and separated from all foreign heterogeneous matters are invariably the same, from what substance so ever it may have been originally obtained.

SAND-BAGS.—*Battery,—Fortification.*

Weight, Dimensions, etc. of Sand-Bags.

	(Empty.)	(Filled.)
Length	2 Feet 8 Inches	2 Feet 3 Inches
Breadth	1 ,, 2 ,,	1 ,, 0 ,,
Thickness		0 ,, 7 ,,

Sand-bags are packed in bales. Each bale contains two hundred bags, and weighs on an average about 1 cwt. In some situations, sand-bags are an excellent substitute for gabions and fascines. If employed in the construction of an epaulment, the number required—supposing the epaulment to be in the form of a prism—will be found by multiplying the number in the base, or ground tier, by the number of tiers, or—supposing it to be in the shape of the frustum of a pyramid—by the rule for computing the number of shot in an incomplete pile. If they are to be used in reveting a work, the number required will be found by multiplying the number in the centre *course by* the number of courses.

SHELLS.—*Artillery,—Calibre,—Windage.*

Weight, Dimensions, etc. in Inches, of Shells for Guns, Howitzers, Mortars, and Carronades.

ORDNANCE.	Calibre. In.	Thickness of Metal.	DIAMETER.				Weight. (Cwt.)	Windage. In.
			Shell.		F. Hole.			
			Greatest.	Least.	External.	Internal.		
GUNS.								
10-Inch Gun	10·000		9·900	9·840	1·22	1·10	·625	·130
68-Pounder............	8·050		7·950	7·850	1·22	1·10	·295	·150
32-Pounder............	6·410		6·207	6·147	1·22	1·10	·134	·233
"	6·350		6·207	6·147	1·22	1·10	·134	·173
"	6·300		6·207	6·147	1·22	1·10	·134	·123
24-Pounder............	5·823		5·620	5·570	·89	·77	·107	·228
18-Pounder............	5·292		5·124	5·074	·89	·77	·080	·193
"	5·170		5·124	5·074	·89	·77	·080	·071
12-Pounder............	4·623		4·476	4·432	·89	·77	·053	·169
9 "	4·200		4·100	4·060	·89	·77	·041	·120
6 "	3·668		3·568	3·532	·89	·77	·026	·118
MORTARS, ETC.								
13-Inch	13·000	2·10	12·880	12·800	1·84	1·70	1.785	·160
10 "	10·000	1·60	9·880	9·800	1·61	1·50	·848	·160
8 "	8·000	1·30	7·950	7·850	1·22	1·13	·366	·100
5½ "	5·620	·85	5·620	5·570	·90	·84	·134	·025
4⅖- "	4·520	·70	4·476	4·432	·82	·77	·067	·066
24-Pounder............	5·720	·85	5·620	5·570	·90	·84	·134	·075
12- "	4·580	·70	4·476	4·432	·82	·77	·067	·126
CARRONADES.								
68-Pounder............	8·050		7·950	7·850	1·22	1·10	·295	·150
42 "	6·840		6·795	6·729	1·22	1·10	·178	·078
32 "	6·250		6·207	6·147	1·22	1·10	·134	·073
24 "	5·680		5·620	5·570	·89	·77	·107	·085
18 "	5·160		5·124	5·074	·89	·77	·053	·061
12 "	4·520		4·476	4·432	·89	·77	·053	·066
6 "	3·610		3·568	3·532	·89	·77	·026	·060
Grenades	..		3·490				·022	..
"	..		2·770				·014	..

Shot.—*Artillery,—Calibre,—Windage.*
Dimensions, etc. in Inches, of Round Shot, for Guns, Howitzers, and Carronades.

ORDNANCE.	Calibre. In.	DIAMETERS.			Windage. In.
		Greatest.	Mean.	Least.	
Field Guns.					
12-Pounder	4·623	4·476	4·454	4·432	·169
9 "	4·200	4·100	4·080	4·060	·120
6 "	3·668	3·568	3·550	3·532	·118
3 "	2·913	2·833	2·818	2·803	·095
1 "	2·019	1·969	1·946	1·923	·073
Siege, etc. Guns.					
10-Inch Gun	10·000	9·880	9·840	9·800	·160
68-Pounder	8·050	7·950	7·925	7·900	·125
32-Pounder	6·410	6·207	6·177	6·147	·233
"	6·350	6·207	6·177	6·147	·173
"	6·300	6·207	6·177	6·147	·123
24-Pounder	5·823	5·639	5·612	5·584	·211
18-Pounder	5·292	5·124	5·099	5·074	·193
"	5·170	5·124	5·099	5·074	·071
12-Pounder	4·623	4·476	4·454	4·432	·169
9 "	4·200	4·100	4·080	4·060	·120
6 "	3·668	3·568	3·550	3·532	·118
Howitzers.					
10-Inch	10·000	9·880	9·840	9·800	·160
8 "	8·000	7·950	7·925	7·900	·075
24-Pounder	5·720	5·639	5·612	5·584	·108
12 "	4·580	4·476	4·454	4·432	·126
Carronades.					
68-Pounder	8·050	7·950	7·925	7·900	·125
42 "	6·840	6·795	6·762	6·729	·078
32 "	6·250	6·207	6·177	6·147	·073
24 "	5·680	5·639	5·612	5·584	·068
18 "	5·160	5·124	5·099	5·074	·061
12 "	4·520	4·476	4·454	4·432	·066
6 "	3·610	3·568	3·550	3·532	·060

DIAMETERS of English and Foreign Shot and Shells in English Inches.

ORDNANCE, ETC.	English.	Austrian.	Baden.	Bavarian.	Danish.	Dutch.	French.
SHOT.							
10-Inch	9·840	..	..	..	..	..	..
68-Pounder	7·925	..	..	..	..	..	..
36 ,,	..	..	..	..	6·693	..	6·661
32 ,,	6·177	..	..	..	..	..	..
30 ,,	..	..	..	..	..	..	6·283
24 ,,	5·611	5·653	5·877	5·664	5·850	5·736	5·876
18 ,,	5·099	5·136	..	5·138	5·314	5·212	5·284
16 ,,	..	..	5·129	..	..	..	5·128
12 ,,	4·454	4·487	4·652	4·489	4·611	4·547	4·618
9 ,,	4·080	..	..	..	..	..	..
8 ,,	..	..	..	..	..	..	4·085
6 ,,	3·550	3·562	3·597	3·563	3·650	3·608	3·685
4 ,,	..	..	..	..	..	..	3·226
3 ,,	2·818	2·826	..	2·892	2·882	2·867	..
SHELLS.							
13-Inch	12·840	..	..	..	..	..	..
2 ,,	..	..	12·612	..	..	..	12·612
10 ,,	9·840	..	10·658	..	..	..	10·658
18 ,,	7·900	..	8 659	..	..	..	8·659
6 ,,	..	..	6·395	..	..	..	6·395
5½ ,,	5·595	..	..	..	..	..	..
4⅖ ,,	4·454	..	..	..	..	..	..
200-Pounder	..	..	..	..	13·879	..	..
150 ,,	..	..	..	..	12·667	..	..
100 ,,	..	..	..	..	11·069	..	..
60 ,,	..	11·661	..	11·667	..	..	..
50 ,,	..	..	..	..	8·779	11·29[illegible]	..
36 ,,	..	..	..	..	7·873	..	..
32 ,,	6·177	..	..	..	..	..	..
30 ,,	..	9·276	..	9·257	..	..	..
24 ,,	5·595	..	..	..	..	5·737	5·861
20 ,,	..	..	..	..	6·554	..	..
18 ,,	5·099	..	..	..	..	..	..
16 ,,	..	..	..	..	..	5·077	..
12 ,,	4·454	..	..	..	..	..	4·785
10 ,,	..	6·418	..	6·425	4·991	..	..
9 ,,	4·080	..	..	..	..	..	..
7 ,,	..	5·698	5·728	5·705	..	..	..
6 ,,	3·550	3·562	..	..	..	..	..

DIAMETERS of English, etc. Shot—*continued*.

ORDNANCE, ETC.	Hanoverian.	Hessian.	Prussian.	Russian.	Saxon.	Spanish.	Wurtemburgh.
SHOT.							
36-Pounder	..	..	..	6·644	..	..	..
32 ,,	..	..	..	..	..	..	..
30 ,,	..	..	..	6·258	..	..	..
24 ,,	5·584	5·663	5·663	5·797	5·673	5·810	..
18 ,,	5·074	5·148	..	5·251	5·154	..	..
16 ,,	..	..	..	..	..	5·074	..
12 ,,	4·432	4·482	4·489	4·579	4·513	4·605	4·512
9 ,,	4·060	..	..	..	..	..	..
8 ,,	..	..	..	..	3·933	4·019	..
6 ,,	3·532	3·563	3·562	3·634	3·574	..	3·564
4 ,,	..	..	..	..	3·122	3·197	..
3 ,,	..	..	2·831	2·884	..	..	..
SHELLS.							
13-Inch	12·795	..	..	..	..	..	..
12 ,,	..	..	..	..	..	12·612	..
10 ,,	9·750	..	..	..	..	..	..
9 ,,	..	..	..	..	..	9·414	..
8 ,,	7·750	..	..	..	..	..	..
6 ,,	..	..	..	..	..	6·395	..
5½ ,,	5·250	..	..	..	..	..	..
4⅖ ,,	4·454	..	..	..	..	..	..
200-Pounder	..	..	..	12·948	..	..	..
150 ,,	..	..	..	..	..	..	..
100 ,,	..	..	..	..	..	..	..
80 ,,	..	..	..	9·488	..	..	..
60 ,,	..	11·698	..	..	..	..	..
50 ,,	..	..	10·998	..	..	..	..
48 ,,	..	..	..	..	10·890	..	..
40 ,,	..	..	..	7·489	..	..	..
32 ,,	..	..	..	..	9·513	..	..
30 ,,	..	9·267	..	..	..	..	..
25 ,,	..	..	8·732	..	..	..	..
20 ,,	..	..	..	5·928	..	..	..
16 ,,	..	..	..	..	7·550	..	..
10 ,,	..	6·378	6·549	4·668	..	..	4·641
8 ,,	..	..	..	..	5·993	..	..
7 ,,	..	5·749	5·664	..	..	..	5·709
6 ,,	..	..	..	3·913	..	..	..

ON THE PILING OF SHOT AND SHELLS.

If the base be either a triangle, or a square, the pile will be pyramidal in form, it will terminate in a single shot or shell, and each of its faces will be an equilateral triangle,—if a rectangle, the form of the pile will be that of a wedge, its end faces will be equilateral triangles, and its side ones, trapezoids; it will consequently terminate in a ridge, or row of shot or shells.

The number of horizontal courses, or rather the number of tiers of shot or shells, in any given pile, is equal to the number in the bottom row or base, of its triangular face; and the number in the upper row or ridge of a rectangular pile is equal to the number in the bottom row or base of the trapezoid plus one, minus the number in the base of its triangular end. Also the number of shot or shells in the triangular face of a pile, is equal to half the number in its base row, multiplied by the number in its base row plus one, and the number of shot or shells in any complete pile is equal to one-third of the product of the number in one of its triangular faces, and the sum of its three parallel edges. In a rectangular pile, the upper row or ridge and the base row of each trapezoid, constitute the three parallel edges,—in the square pile, the single shot or shell at the top, and the base rows of the two opposite triangular faces, and in the triangular pile, the upper shot or shell, the base row of one of the triangular faces, and the single shot or shell at the back of the pile, constitute the three parallel edges.

If the pile, of which the content is required, be incomplete, compute its content by the above rule, supposing it to be complete,—compute also the content of the upper pile, or part wanting to complete it, and the difference of the contents of these two piles, will be the content, or number of shot or shells in the *frustum*, or incomplete pile.

By means of this table, not only may piles of shot and shells, within certain limits, be constructed, but the contents of such as are already constructed, may be at once ascertained on inspection.

The figures, or natural numbers, 2, 3, 4, 5, etc. in the second diagonal, and 1, 2, 3, 4, 5, etc. in the first vertical column, or the numerals by which the several horizontal, and vertical columns are respectively signed, denote the number of shot, or shells in the base row, or rows, of the respective piles.—Each compound number, in the first diagonal column, denotes the content of the triangular pile corresponding to the natural number on its left, and each number, in the body of the table, the content of that pile, square or rectangular, which corresponds with the signatures of the columns at the intersection of which it is found.

If the number of shot, for example, in the base row of a triangular pile be 7, 84 will be its content; and if the numbers in the length and breadth of the base of a rectangular pile be 16 and 10, its content will be 715.

The arithmetical progression, or horizontal column, signed C. D., at the bottom of the table, shews the common differences of the several rectangular piles.

1	2	4																				
2	5	3	10																			
3	8	14	4	20																		
4	11	20	30	5	35																	
5	14	26	40	55	6	56																
6	17	32	50	70	91	7	84															
7	20	38	60	85	112	140	8	120														
8	23	44	70	100	133	168	204	9	165													
9	26	50	80	115	154	196	240	285	10	220												
10	29	56	90	130	175	224	276	330	385	11	286											
11	32	62	100	145	196	252	312	375	440	506	12	364										
12	35	68	110	160	217	280	348	420	495	572	650	13	455									
13	38	74	120	175	238	308	384	465	550	638	728	819	14	560								
14	41	80	130	190	259	336	420	510	605	704	806	910	1015	15	680							
15	44	86	140	205	280	364	456	555	660	770	884	1001	1120	1240	16	816						
16	47	92	150	220	301	392	492	600	715	836	962	1092	1225	1360	1496	17	969					
17	50	98	160	235	322	420	528	645	770	902	1040	1183	1330	1480	1632	1785	18	1140				
18	53	104	170	250	343	448	564	690	825	968	1118	1274	1435	1600	1768	1938	2109	19	1330			
19	56	110	180	265	364	476	600	735	880	1034	1196	1365	1540	1720	1904	2091	2280	2470	20	1540		
20	59	116	190	280	385	504	636	780	935	1100	1274	1456	1645	1840	2040	2244	2451	2660	2870	21	1771	
21	62	122	200	295	406	532	672	825	990	1166	1352	1547	1750	1960	2171	2397	2622	2850	3080	3311	22	2024
C.D.	3	6	10	15	21	28	36	45	55	66	78	91	105	120	136	153	171	190	210	231	253	276

Weight, Dimensions, etc. in Inches, of Case-Shot, for Guns, Howitzers, and Carronades.

ORDNANCE.	Nature of Shot.	No. in each Case.	Dimensions.				No. in each Box.	Weight.
			Case.		Bottom.			
			Length.	Breadth.	Diameter.	Thickness.		
	Ozs.							Lbs.
Field Guns.								
12-Pounder	2·000	168	14·40	8·50	4·25	1·100	8	17·375
,,	6·500	41	14·40	8·70	4·25	1·100		16·500
9-Pounder	1·500	126	13·20	7·95	4·00	1·000	12	13·000
,,	5·000	41	13·20	7·70	4·00	1·000		13·250
6-Pounder	1·500	85	11·50	7·20	3·50	·980	15	8·750
,,	3·250	41	11·50	6·90	3·50	·980		9·000
3-Pounder	1·500	41	9·11	4·70	2·70	·790	30	4·375
Siege, etc. Guns.								
10-Inch Gun	16·000	34	31·35	9·00	9·67	·165		82·500
,,	13·125	50	31·35		9·67	·165		
68-Pounder	8·000	90	24·50	8·20	7·60	1·900	3	46·500
42 ,,	8·000	66	19·80	9·00	5·90	1·320	4	33·500
24 ,,	8·000	46	18·12	8·40	5·30	1·290	6	23·500
18 ,,	6·000	46	16·50	8·00	4·75	1·200	6	19·000
12 ,,	4·000	46	14·40	6·60	4·25	1·100	12	11·750
9 ,,	3·000	44	13·20	6·20	4·00	1·000	14	8·500
6 ,,	2·000	40	11·50	5·10	3·50	·980	24	5·750
Howitzers.								
10-Inch	8·000	170	31·70	9·20	9·77	5·500	2	86·250
8 ,,	2·000	285	24·80	5·80	7·60	5·000	3	35·000
4⅖ ,,	2·000	55	14·40	4·30	4·25	2·750	12	7·750
24-Pounder	2·000	140	18·12	6·30	5·30	·165	10	19·250
12 ,,	2·000	84	14·40	4·30	4·25	·165	12	11·750
Carronades.								
68-Pounder	8·000	90	24·50	8·20	7·60	1·450	3	46·500
42 ,,	8·000	66	21·60	7·70	6·45	1·350	4	34·250
32 ,,	8·000	40	19·80	6·40	5·90	1·000	4	21·250
24 ,,	8·000	32	17·90	6·20	5·30	·850	8	16·375
18 ,,	6·000	31	15·80	5·60	4·75	·800	8	13·000
12 ,,	4·000	32	13·80	4·90	4·25	·750	12	8·375
6 ,,	2·000	30	11·30	4·30	3·50	·700	20	4·375

Materials required to complete 100 Case-Shot for each of the undermentioned natures of Ordnance.

ORDNANCE.	MATERIALS.							
	Shot. No.	Nails.	Bottoms.	Iron Plates.	Tin Plates.	Solder.	Rosin.	Charcoal. Bsk.
Field Guns.								
12-Pounder	16800	1·250	100	..	125	7	·750	2·00
„	4100		100	..	125	7	·750	2·00
9-Pounder	12600		100	..	118	7	·750	1·50
„	4100		100	..	118	7	·750	1·50
6-Pounder	8500	1·000	100	..	118	6	·750	1·50
„	4100		100	..	118	6	·750	1·50
3-Pounder	4100	·750	100	..	59	4	·500	1·00
Siege, etc. Guns.								
10-Inch Gun	3400	..	..	100	..	..	..	..
„	5000	..	..	100	..	..	..	..
68-Pounder	9000	2·375	100	..	300	11	1·000	3·00
32 „	6600	1·750	100	..	200	10	1·000	3·00
24 „	4600	1·500	100	..	200	9	1·000	3·00
18 „	4600	1·375	100	..	134	8	·875	2·50
12 „	4600	1·125	100	..	125	7	·750	2·00
9 „	4400	1·125	100	..	125	6	·750	1·50
6 „	4000	1·000	100	..	52	5	·750	1·50
Howitzers.								
10-Inch	17000	2·500	100	..	300	12	1·000	3·00
8 „	28500	2·375	100	..	300	9	·875	2·50
4⅖ „	5500	1·375	100	..	75	5	·870	1·50
24-Pounder	14000	..	..	8	100			2·50
12 „	8400	..	..	6	50			2·00
Carronades.								
68-Pounder	9000	2·375	100	..	300	11	1·000	3·00
42 „	6600	2·000	100	..	300	11	1·000	3·00
32 „	4000	1·750	100	..	150	9	·875	2·50
24 „	3200	1·500	100	..	150	9	·875	2·50
18 „	3100	1·375	100	..	134	7	·750	2·00
12 „	3200	1·125	100	..	75	5	·625	1·50
6 „	6000	1·000	100	..	63	4	·500	1·25

Weight, Dimensions, etc. in Inches of Grape-Shot, for Guns and Carronades.

ORDNANCE.	Nature of Shot. Lbs.	No. in each Grape.	Dimensions.				No. in each Box.	Weight. Lbs.
			Case.		Bottom.			
			Length.	Breadth.	Diameter.	Thickness.		
Guns.								
(Canvas.)								
10-Inch Gun								
68-Pounder	3·00	15	24·00	17·00	7·78	·64	3	50·500
32 "	3·00	9	17·80	16·00	6·10	·55	4	32·000
24 "	2·00	9	16·40	14·50	5·54	·48	6	22·000
18 "	1·50	9	14·80	12·12	5·03	·44	8	16·500
12 "	1·00	9	13·15	11·00	4·40	·38	12	11·625
9 "	·82	9	12·40	10·00	4·00	·36	14	9·625
6 "	·50	9	10·40	9·11	3·48	·30	20	6·375
(Iron Plate.)								
10-Inch Gun								
68-Pounder								
32 "	3·00	9	..	..	6·15	·41	4	36·375
24 "	2·00	9	..	..	5·56	·41	6	25·625
18 "	1·50	9	..	..	5·05	·31	8	19·250
12 "	1·00	9	..	..	4·44	·28	12	13·250
9 "	·82	9	..	..	4·03	·24	14	10·375
6 "	·50	9	..	..	3·50	·22	20	6·375
Carronades.								
(Canvas.)								
68-Pounder	3·00	15	24·00	17·00	7·78	·64	3	50·500
42 "	4·00	9	20·00	17·10	6·68	·61	4	42·625
32 "	3·00	9	17·80	16·00	6·10	·55	4	36·375
24 "	2·00	9	16·40	14·50	5·54	·48	6	25·625
18 "	1·50	9	14·80	12·12	5·03	·44	8	19·255
12 "	1·00	9	13·15	11·00	4·40	·38	12	13·250
6 "	·50	9	10·40	9·10	3·48	·30	20	6·370
(Tin Case.)								
68-Pounder	3·00	15	24·70	9·20	7·60	1·45		
42 "	4·00	9	21·30	9·79	6·45	1·35		
32 "	3·00	9	19·22	9·60	5·90	1·00		
24 "	2·00	9	17·40	7·80	5·30	·85		
18 "	1·50	9	15·80	6·90	4·75	·80		
12 "	1·00	9	13·90	6·50	4·25	·75		
6 "	·50	9						

MATERIALS required to Complete 100 Grape-Shot for each of the undermentioned Guns and Carronades.

ORDNANCE.	MATERIALS.						
	No. Shot.	Tompions.	Iron Plates.	Tin Plates.	Canvas. (Yds.)	Line. (Yds.)	Thread. (Oz.)
GUNS.							
(Canvas.)							
10-Inch Gun							
68-Pounder	1500	100	..	..	47·5	417	3.30
32 „	900	100	..	..	34·0	295	2·50
24 „	900	100	..	..	27·0	239	2·25
18 „	900	100	..	..	22·0	231	2·25
12 „	900	100	..	..	15·0	212	2·25
9 „	900	100	..	..	14·0	200	2·00
6 „	900	100	..	..	11·0	167	2·00
(Iron Plate.)							
10-Inch Gun							
68-Pounder							
32 „	900	100	300	..	..	..	..
24 „	900	100	300	..	..	..	..
18 „	900	100	300	..	..	..	..
12 „	900	100	300	..	..	..	..
9 „	900	100	300	..	..	..	..
6 „	900	100	300	..	..	..	..
CARRONADES.							
(Canvas.)							
68-Pounder	1500	100	..	..	47·5	417	3·00
42 „	900	100	..	..	39·0	334	2·50
32 „	900	100	..	..	34·0	295	2·50
24 „	900	100	..	..	27·0	239	2·25
18 „	900	100	..	..	22·0	231	2·25
12 „	900	100	..	..	15·0	212	2·25
6 „	900	100	..	..	11·0	167	2·00
(Tin Case.)							
68-Pounder	1500	100	..	300	..	..	..
42 „	900	100	..	300	..	..	..
32 „	900	100	..	200	..	..	..
24 „	900	100	..	200	..	..	..
18 „	900	100	..	134	..	..	..
12 „	900	100	..	125	..	..	..
6 „	900	100	..				

OBSERVATIONS ON FIRING GRAPE AND CASE-SHOT.

The balls of grape and case-shot are observed, when discharged from a gun, or other piece of ordnance, to take, at first, a diverging direction, and, for a certain distance, to form a species of irregular cone, the base of which is towards the object fired at, and the vertex towards the gun.

It is impossible, from theory alone, to deminine the direction that each individual ball takes after the case is broken, since the contact of the balls, and their reciprocal pressures at the instant of the discharge, and at the commencement of their divergence, are unknown. It should therefore be ascertained, as far as possible, by experiment.

The following results have been obtained from a series of experiments conducted with the utmost care and attention:—

1. The conical figure is preserved to a certain distance, after which it is entirely lost.

2. The distance from the point of formation of the cone to that at which it begins to lose the regularity of its figure depends upon the size of the balls, and the velocity with which they are discharged.

3. Balls propelled from guns of the ordinary length diverge much less than balls of the same weight and diameter propelled from shorter guns with the same charge.

4. By encreasing the number of balls in the case, the initial velocity and consequent effect of each is proportionally diminished.

5. Balls which are ranged in the case or cylinder, in regular order, or in tiers, diverge much less than balls put into the cases or cylinders, irregularly or haphazard.

6. Case-shot produces its greatest effect, when the object fired at, or the enemy's troops are drawn up on ground inclined towards the gun.

7. The use of case-shot should commence at ranges not exceeding four hundred yards, and the rapidity of the fire should encrease in proportion as the extent of the range diminishes. If great precision be not required in laying the gun, three rounds may be fired in a minute.

8. Double charges may be advantageously used at ranges not exceeding one hundred and fifty yards.

9. The line of direction of a gun loaded with grape or case-shot should be rather over than under the object fired at, but the extent, or degree of this elevation must depend upon the distance of the object from the gun.

Grenades were quilted into grape at the siege of Gibraltar. The fuzes were turned inwards next the pin of the tampion, and quick-match leaders were introduced through holes in its bottom. They were fired from 13-inch mortars, and answered extremely well at short ranges.

ON THE WEIGHT AND DIMENSIONS OF SHOT AND SHELLS.

The weight, or dimensions of a shot, or shell, may be readily determined by means of its specific gravity. But a shot, four inches in diameter, weighs 9·0029 pounds, and similar solids are to each other as the cubes of their like linear dimensions. Also, the specific gravity of gunpowder, in a closely shaken mass, is 920,—Consequently, a cubic foot of the mass weighs 57·5 pounds, and one pound of it, occupies thirty cubic inches. . Hence, on these data, neglecting the fractional weight of the given shot, may the weight, dimensions, or capacity of any other shot, or shell, be still more readily ascertained.

1. *Given the Diameter of a Shot to find its Weight.*

Multiply the cube of the given diameter, in inches, by 9, and the product, divided by 64, will be the weight required, in pounds.

The diameter of a shot being 6·7 inches, required its weight?

$$\text{Here, } (300{\cdot}763\times9)\div64=42{\cdot}295 \text{ Lbs.}$$

2. *Given the Weight of a Shot to find its Diameter.*

Divide the given weight, in pounds, multiplied into 64, by 9, and the cube root of the quotient will be the diameter required, in inches.

The weight of a shot being 42 pounds, required its diameter?

$$\text{Here, } \left(\frac{42\times64}{9}\right)^{\frac{1}{3}}=6{\cdot}753 \text{ Inches.}$$

3. *Given the Dimensions of a Shell to find its Weight.*

Multiply the difference of the cubes of the internal and external diameters of the given shell, in inches, by 9, and the product, divided by 64, will be the weight required, in pounds.

The internal and external diameters of a shell being 8·65, and 12·8 inches respectively required its weight?

$$\text{Here, } \Big((2097{\cdot}152-647{\cdot}215)\times9\Big)\div64=204{\cdot}6 \text{ Lbs.}$$

4. *Given the Weight and External Diameter of a Shell, to find its Internal Diameter.*

Divide the difference of the weights of the given shell, and of a shot of the same diameter multiplied into 64, by 9, and the cube root of the quotient will be the internal diameter required in inches.

The external diameter of a shell being 6·05 inches, and its weight 22 pounds, required its internal diameter?

$$\text{Here, } \left((31{\cdot}14-22\times64)\div9\right)^{\frac{1}{3}}=4{\cdot}02 \text{ Inches.}$$

5. *Given the Internal Diameter of a Shell to find its Capacity, or Content.*

Multiply the cube of the given diameter, in inches by ·5236, and the product will be the content or capacity required.

The internal diameter of a shell being 8·65 inches, required its capacity or content?

$$\text{Here, } 647{\cdot}2146\times{\cdot}5236=338{\cdot}882 \text{ Cubic Inches.}$$

6. *Given the Capacity or Content of a Shell to find the quantity of Powder it will contain.*

Divide the given content or capacity, in cubic inches, by 30, and the quotient will be the quantity of powder required, in pounds.

The capacity, or content of a shell being 338·881 cubic inches, required the quantity of powder it will contain?

$$\text{Here, } 338{\cdot}881\div30=11{\cdot}296 \text{ Lbs.}$$

7. *Given the quantity of Powder a Shell will contain to find its Internal Diameter.*

Multiply the given weight of powder, in pounds, by 57·5, and the cube root of the product, will be the diameter required, in inches.

The weight of powder which a shell will contain being 6 pounds, required its internal diameter?

$$\text{Here, } \left(6\times57{\cdot}5\right)^{\frac{1}{3}}=7{\cdot}0123 \text{ Inches.}$$

8. *Given the Internal Diameter of a Shell to find the quantity of Powder it will contain.*

Divide the cube of the given diameter, in inches, by 57·5, and the quotient will be the weight of the powder required, in pounds.

The internal diameter of a shell being 7·0123 inches, required the quantity of powder that it will contain?

Here, 344·812÷57·5=5·99 Lbs.

9. *Given the Dimensions of a Cylinder, to find the quantity of Powder it will contain.*

Multiply the square of the diameter of the given cylinder by the length of its axis, both in inches, and the product, divided by 38·2, will be the quantity of powder required, in pounds.

The diameter and axis of a cylinder being respectively 10, and 20 inches, required the quantity of powder it will contain?

Here, (100×20)÷38·2 =52·356 Lbs.

10. *Given the Diameter of a Cylinder, and the quantity of Powder that it will contain, to find its Length.*

Divide the product of the given weight of powder, in pounds, multiplied into 38·2, by the square of the diameter, and the quotient will be the length required, in inches.

The diameter of a cylinder being 6·4 inches, required what length of it will be filled by 12 pounds of powder?

Here, (12×38·2)÷40·96=11·119 Inches.

Slow-Match,—*Artillery.*

In this country, slow-match is prepared by soaking white hempen or flaxen rope, slightly twisted, in a strong lye. It is made up in skeins, and burns at the rate of one yard in eight hours. Each hundred pounds of rope requires, in its preparation, fifty pounds of wood ashes, and twenty-five of lime. In France, the rope is soaked in a solution of rain water and sugar of lead mixed in the proportion of six ounces of lead to each gallon of water. French slow-match burns at the rate of five inches in one hour.

Smoke-Balls.—*Composition.*

Dimensions, etc. of Smoke-Ball Cases.

SMOKE-BALLS.	Calibre. In.	Diameter.				Thickness. In.
		Case.		Fuze-Hole.		
		Internal.	External.	Internal.	External.	
10-Inch	10·00	·717	·813	·121	·131	1·15
8 „	8·00	·554	·646	·102	·110	1·10
5½ „	5·62	·396	·462	·069	·075	·79
4⅖ „	4·52	·313	·367	·064	·069	·65

The above are the exact dimensions of the cases when completed and perfectly dry.

Implements required:—

Formers.
Guages.
Knives.
Rasps.
Scissors.

Paste Tubs.
Brushes.
Punches.
Reamers.
Irons.

The composition is put into the case warm. It must therefore be rolled up in pieces about three inches in length, and of such a thickness as will allow of its passing freely in at the fuze-hole. Five or six pieces should be put into the case at a time, and should then be set down with the loading stick from the centre to the sides, the end of the stick being occasionally greased, otherwise the composition will adhere to it.

Implements required:—

Mixing Tables.
Rubbers.
Hair Sieves.
Iron Pots.
Copper Pans.
Spatulas.

Loading Sticks.
Grease Boxes.
Fuze Plugs.
Drifts.
Ladles.
Mallets.

Materials required to complete 10 of each of the undermentioned Smoke-Balls.

MATERIALS.		Smoke-Balls.			
		10-Inch.	8-Inch.	5½-Inch.	4⅖-Inch.
Cartridge Paper	Quires.	6·834	2·500	1·500	·788
Flour	Lbs.				
Saltpetre	„	17·250	10·000	7·000	4·000
Sulphur	„	2·125	1·125	1·000	·750
Gunpowder	„	85·000	50·000	35·000	20·000
Tallow	„	9·750	5·000	3·500	2·000
Quick Match	„	·062	·047	·032	·032
Sea Coal	„	27·625	16·250	11·375	6·500
Pitch	„	34·000	20·000	14·009	8·006

Sound.—*Distance,—Pendulum.*

The cause of the sensation of sound is the movement communicated to the particles of the air by the vibrations of a sonorous body; and it is because the particles are driven from the point of vibration in every direction as from a centre, that the sound is perceived at once every where within the surface of a sphere of a certain extent.

Sir Isaac Newton proves, by the analogy which the pulsations of the air have with the waves produced by a stone falling in water, and also with the vibrations of a pendulum that an aëriel pulse will be propagated forward through a space equal to the circumference of a circle, the radius of which is equal to the height of an homogeneous atmosphere, in the time that a pendulum, equal in length to that radius, would make one double oscillation. He supposes the height of such an atmosphere to be 29,725 feet; and since a pendulum, 39·167 inches long would make one double oscillation in two seconds, he infers by the theory of vibrations, that a pendulum, equal in length to the height of the atmosphere would make one double vibration in 190·25 seconds, during which time, from what has been said, the particles of the air would be carried through 186,768 feet, and therefore through 979 feet in one second. And this of course would express, the velocity of sound if the air were perfectly elastic. The difference between this result, and the observed velocity of sound, is ascribed by Sir Isaac Newton to the thickness of the solid particles of the air, and to the vapours which float in the atmosphere. But it is evident that the modifications to which the velocity of sound is subject on account of these circumstances must be very uncertain. In determining the distances of objects by sound therefore, we must content ourselves with the results of experiment till a more perfect theory shall be discovered.

The first experiments made for the purpose of ascertaining the velocity of sound seem to have given results which are much too great, and in proportion as more care has been taken in conducting them, the velocity has been found to be less. Mr. Roberts determined it to be at the rate of 1300 feet per second, and by M. Arago it was found to be 1106·33 feet. The experiments made by Dr. Gregory in 1823, at Woolwich, prove it to be still less, and the results which he has obtained may perhaps be considered as approaching extremely near the truth.

Dr. Gregory employed the fire of guns, mortars, and muskets, when the wind was scarcely perceptible,—when the velocity of the wind was from 24 to 30 feet per second; in one case towards the observer, and in another when directly from the observer; again, when the muzzle of the piece was turned towards the observer, and when it was turned from the observer. The height of the barometer during the experiments was from 29·64 to 29·98 inches, and the temperature, ascertained by Fahrenheit's thermometer, was from 27 to 66 degrees. Lastly, the distance from the piece to the observer varied from 13,440 to 2,100 feet.

The results were, that at the temperature expressed by 33 degrees, the velocity is 1,100 feet per second, when not affected by the wind,—that, for every degree of the thermometer below 33 degrees, half a foot is to be deducted, and for every degree above 33 degrees half a foot is to be added to the above number, in order to express the velocity. If the direction of the wind coincides with that in which the sound is heard, it increases the velocity of the sound by a quantity equal to its own velocity, and when the direction of the wind is contrary to that of the sound, it diminishes the velocity of the latter by the same quantity. Finally, no difference was observed in the velocity whether the muzzle of the piece was directed towards, or from the observer, but the intensity was considerably diminished in the latter case. The velocities of direct and reflected sound were found to be equal, and it was found that the velocity is not affected by the intensity of the sound, the smallest sound moving as quickly as the loudest. Dr. Gregory further concludes, from a comparison of his own experiments with those made by Mr. Goldingham at Madras, that in different climates there is a small difference in the velocity of sound.

In order to ascertain the distance of any object by the report of fire arms, the following rule may be given. Multiply the number of seconds which elapse between seeing the flash and hearing the report by 1100, and the product will be the distance, in feet, with sufficient accuracy for ordinary purposes. If greater accuracy be required, this rule must be modified on account of the velocity and direction of the wind, and the state of the thermometer as above shewn.

Spikes.—*Artillery,—Dispart,—Vent.*

Spikes are of two kinds. The spring spike, and the conical, or common spike, which serves for all natures of ordnance. The conical spike is four inches long, ·275 of an inch in diameter at the head, and about ·1 of an inch at the point. The spring spikes are all ·19 of an inch in diameter,—they are perfectly cylindrical and vary in length from 2·128 to 5·602 inches, the length of the spring not included, according to the nature of the ordnance for which they are issued.

Sulphur.—*Composition,—Gunpowder.*

A combination of vitriolic acid with a combustible substance. It is brittle, of a pale yellow color, somewhat translucent, insipid, and inodorous, but exhaling a peculiar smell when heated. It becomes negatively electrical by heat, or friction, and is a nonconductor of electricity. Massive, or native sulphur, that which is principally used in this country, is a natural product of Sicily, whence it is procured in enormous quantities. It is very inflammable, suffers no change by exposure to the air, and is insoluble in water.

Tackles.—*Artillery,—Exercise.*

Weight, Dimensions, etc. of Tackles.

Triangle Gyn.

Rope, White 3½ Inch, 12 Fathoms	26 Lbs.
Blocks, Triple 12 Inch	64
„ Double 12 „	54

Weight Complete.. 144 Lbs.

Sling Cart.

Lever Ropes, Tarred 2 Inch, 4 Fathoms	7 Lbs.
Sling „ White 5½ „ 2½ „	13

Weight Complete.. 20 Lbs.

Devil Carriage.

Preventive	Rope,	Tarred,	2½ Inch,	9	Fathoms,	10 Lbs.
Breech	„	„	2½ „	6	„	7
Carriage	„	„	2½ „	3	„	4
Gug	„	„	2½ „	13	„	28

Weight Complete.. 49 Lbs.

Luff.

Rope, Tarred 2½ Inch, 9 Fathoms	14 Lbs.
Blocks, Double 8 Inch	8½
„ Single 8 „	6½

Weight Complete.. 29 Lbs.

Tangent-Scale.—*Dispart,*—*Distance,*—*Carronade.*

Tangent-scales are adjusted with reference to the dispart and length of the gun, howitzer or carronade to which they are to be applied. If the scale is to be applied above the base-ring, the dispart must be subtracted from the length of the tangent prior to its application,—if it is to be applied at the quarter sight, no deduction whatever must be made in the length of the scale.

Hence, to find the length of the scale for a proposed elevation, multiply the length of the given gun, in inches by the tangent of the angle corresponding to the proposed elevation, and the product will be the length of the scale required, also in inches.

Tents. —*Camp,*—*Park.*

Weight, Dimensions, etc. of Tents.

Captain's Marquee.

Standards,	Length	8·00	Feet.	Diameter	2·25	Inches.
Ridge-Pole ..	„	7·00	„	„	2·25	„
Door-Standards	„	6·25	„	„	1·50	„

Pins, Large	4	Mallets....	2
„ Small	96	Weight Complete	142 Lbs.

Standards and Ridge Poles each in two pieces.

Subaltern's Marquee.

Standards,	Length	8·0	Feet.	Diameter	2·25	Feet.
Ridge Pole,	„	6·0	„	„	2·25	„
Door Standards,	„	6·0	„	„	1·50	„

Pins, Large .... 4 Mallets.... 2
„ Small .... 6 Weight Complete 134 Lbs.

Circular Tent.

Standard, Length 10·25 Feet. Diameter 2 Inches.
Pins ....20 Mallets 2
Weight Complete 53 Lbs.

Mess Tent.

Standard, Length 12·5 Feet. Diameter 3·5 Inches.
Pins, Large .... 4 Mallets....2.
„ Small ....78 Weight Complete 142 Lbs.

Hospital Tent.

Standards,	Length	13·50	Feet.	Diameter	2·5	Inches.
Ridge-Pole	„	13·25	„	„	2·5	„
Door Standards	„	6·75	„	„	2·0	„

Pins, Large .... 4 Mallets 2
„ Small ....180 Weight Complete 371 Lbs.

Laboratory Tent.

Standard, Length 16·25 Feet. Diameter 5 Inches.
Pins, Large .... 4 Mallets 2
„ Small ....100 Weight Complete 234 Lbs.

Each Standard and Ridge-Pole of these Tents is in two pieces.

TONNAGE.—*Embarkation,—Transport.*

In computing the tonnage of a vessel, or its means of transport, forty cubic feet make one ton. Carriages, and in general all bulky stores are estimated for by measurement, and should therefore be taken to pieces and packed in the smallest possible compass. Ordnance and heavy articles of all kinds are taken according to their actual weight.

Tools.—*Artillery.*

Detail of Implements and Tools for the Artificers attached to a Field Battery, or Battery of Horse Artillery Equipped for Foreign Service.

IMPLEMENTS, ETC.	Number.	OBSERVATIONS.
FARRIER'S.		*With the Forge Waggon.*
Chisels, Hot	1	Forge Tools.
Fullers	2	„ „
Hammers, Hand, 3 lbs.....	1	„ „
„ Sledge 10 „	1	„ „
Pokers	1	„ „
Pritchets....	2	„ „
Slices	1	„ „
Stamps	2	„ „
Tongs ....pairs	1	„ „
Boxes	2	Shoeing Tools.
Buffers....................	3	„ „
Hammers, Pointing	2	„ „
„ Shoeing	2	„ „
Knives, Drawing	6	„ „
„ Paring	3	„ „
„ Searching..	3	„ „
„ Toeing	3	„ „
Pincers ....pairs	2	„ „
Rasps	9	„ „
Stakes, Pointing	2	„ „
Twitchers	2	„ „
Physic .... lbs.	1	The proportion of Medicines, here given, is considered sufficient for 120 horses for two months. It is proposed to place a proportion and a half, or sufficient for 180 horses, packed in a box fitted with canisters, etc. in each Store Waggon, and a box, similarly fitted, containing half a proportion in the Limber box of each Forge Waggon in charge of the Farrier.
Diuretic Balls .... „	2	
Fever „ .... „	1	
Gripe „ .... „	2	
Blistering Ointment.... „	2	
Wound „ .... „	2	
Blue Vitriol .... „	2	
Alum .... „	8	
Nitre.................. „	1	
Sugar of Lead.......... „	1	
Culinary Salt .... „	4	
Tow .... „	4	
Cloth for Bandages		
Paper for Balls		
Clyster Pipes	1	Medical Tools.
Bladders	12	„ „
Bits	1	„ „
Straps	1	„ „

IMPLEMENTS AND TOOLS—*continued.*

IMPLEMENTS.	Number.	OBSERVATIONS.
FARRIER'S—*continued.*		***With the Forge Waggon.***
Drenching Horns	1	Medical Tools.
Balling Shoots	1	,, ,,
Rasps, Mouth	1	,, ,,
Ladles, 7-Inch	1	,, ,,
4 ,,	1	,, ,,
Bleeding Sticks	1	,, ,,
Phlemes ... cases	1	3 Phlemes in each case.
Scissors ... pairs	1	
Shears ... ,,	1	
CARRIAGE SMITH'S.		***With the Forge Waggon.***
Braces	1	
Bits, Square	1	For the Braces.
,, Half-round	1	,, ,, ,,
,, Countersank	1	,, ,, ,,
Chisels, Cold, Hand	1	
,, ,, Rod	1	
,, Hot	1	
Compasses, 7-Inch ... pairs	1	
Callipers, 9 ,, ... ,,	1	
Drill Bows	1	
Breast Plates	1	
Boxes	6	For the Drills.
Catgut ... knots	6	,, ,,
Drills	4	
Stocks	1	
Files, Rubbers, 16-Inch	3	Cut, Bastard.
,, Flat, 14-Inch	10	,, ,,
,, ,, 10 ,,	6	,, ,,
,, ,, 8 ,,	4	,, ,,
,, Half-round, 14-Inch	4	,, ,,
,, ,, 10 ,,	4	,, ,,
,, Round, 12-Inch	4	,, ,,
,, ,, 8 ,,	2	,, ,,
,, Four-square, 10-Inch	2	,, ,,
,, ,, 8 ,,	2	,, ,,
,, Three-square, 12-Inch	1	,, ,,
,, ,, 7 ,,	1	,, ,,
,, Warding, Smooth	2	Cut on one side.
File Handles	6	
Pincers ... pairs	1	
Punches, 3 sizes	3	

IMPLEMENTS AND TOOLS—*continued.*

IMPLEMENTS, ETC.	Number.	OBSERVATIONS.
CARRIAGE SMITH'S—*continued.*		***With the Forge Waggon.***
Hammers, Sledge, 12 lbs.	1	
,, ,, 7 ,,	1	
Hand 3½ lbs.	1	
Bench 1½ lbs.	1	
Set 3, lbs.	1	
Saws, Slitting	1	
Squares, Iron	1	Graduated.
Oil Stones, Turkey	1	Small Size.
Screw Drivers, 6-Inch	1	
Stocks and Dies ....Sets	1	Middling Sizes.
Screw Plates and Taps	1	Small.
Tongs, Fore Bit..........Pairs	1	
,, Plyer .... ,,	1	
,, Hammer .... ,,	1	
,, Hollow Bit	1	
,, Boat	1	
Vices, Standing 36-lbs.	1	
,, Hand	1	
Wrenches, Wedge	1	
Rules, 2-Feet	1	
WHEELER'S.		*With the Spare Gun Carriag*
Broad Axes, 6½ lbs.	1	
Adzes, 5½ lbs.	1	
Bradawls	6	With Handles.
,,	18	Without Handles.
Augers $\frac{4}{8}$ Inch	1	With Handles.
,, $\frac{5}{8}$,,	1	,, ,,
,, $\frac{6}{8}$,,	1	,, ,,
,, $\frac{7}{8}$,,	1	,, ,,
,, $\frac{8}{8}$,,	1	,, ,,
,, $\frac{9}{8}$,,	1	,, ,,
,, $\frac{10}{8}$,,	1	,, ,,
,, $\frac{12}{8}$,,	1	,, ,,
Bevels, Steel Blade	1	
Tool Bags	1	
Buzzes, ¾-Inch	1	
,, 1 ,,	1	
Crow Bars, 7-lbs.	1	
Drawing Knives, 10 Inch	2	

Implements and Tools—*continued.*

IMPLEMENTS, ETC.	Number.	Observations
Wheeler's—*continued.*		*With the Spare Gun Carriage.*
Compasses, Wing, 12-Inch Pairs	1	
7 ,, ,,	1	
Chisels, Cold, Hand	2	$\frac{3}{4}$ by 8-inch.
,, ,, Rod	2	
,, ,, Firmer $\frac{1}{2}$-Inch ..	1	
,, ,, ,, $\frac{3}{4}$,, ..	1	
,, ,, ,, 1 ,, ..	1	
,, ,, ,, $1\frac{1}{2}$,, ..	1	
,, ,, Socket $\frac{4}{8}$-Inch ..	1	
,, ,, ,, $\frac{5}{8}$,, ..	1	
,, ,, ,, $\frac{6}{8}$,, ..	1	
,, ,, ,, $\frac{8}{8}$,, ..	1	
,, ,, ,, $\frac{10}{8}$,, ..	1	
,, ,, ,, $\frac{12}{8}$,, ..	1	
,, ,, ,, $\frac{16}{8}$,, ..	1	
Files, Handsaw	18	
,, Tenon ,, ...	12	
,, Half-Round, 12-Inch	1	Bastard.
,, Flat, 14-Inch	1	
,, Round, 14-Inch	1	
,, Rasps, 12-Inch..........	1	
Gimblets, Common............	12	
,, Spike	6	
Guages, Boxing, 2-Inch	1	
,, ,, $1\frac{1}{2}$,, ...	1	
,, Scribing $\frac{2}{8}$-Inch	1	
,, ,, $\frac{3}{8}$,, ...	1	
,, ,, $\frac{4}{8}$,, ...	1	
,, ,, $\frac{5}{8}$,, ...	1	
,, Pecking $\frac{5}{8}$-Inch	1	
,, Single and Mortice	2	
Hammers, Sledge ..10-lbs.	1	
,, Rivetting $1\frac{1}{2}$-lbs.	1	
,, Hand $3\frac{1}{2}$-lbs.	1	
Chalk Lines and Reels	1	
Mallets	1	
Pencils, Black Lead	12	
Draw Bore Pins, Iron	2	
Planes, Jack	1	
,, Trying...	1	

IMPLEMENTS AND TOOLS—*continued.*

IMPLEMENTS, ETC.	Number.	OBSERVATIONS.
WHEELER'S—*continued.*		*With the Spare Gun Carri*
Planes, Smoothing	1	
„ Rebate 1½-Inch	1	
„ Bead ⅜-Inch	1	
Glue Pots and Brushes	1	
Pincers ... Pairs	1	
Punches	2	
Rules, 2-Feet	1	
Saws, Hand	1	
„ Tenon	1	
„ Compass	1	
Saw Setters	1	
Oil Stones, Turkey	1	
Rub Stones, 12-Inch	1	
Rag Stones	1	
Wrenches	1	
Screw Drivers, 6-Inch	1	
„ 14 „	1	
Spoke Shaves, 3-Inch	1	
„ 4 „	1	
Squares, Iron	1	
„ Wood, 12-Inch	1	Graduated.
„ „ 9 „	1	
Stock with 24 Bits	1	With Steel Blade.
COLLAR MAKER'S.		*With the Store Waggon.*
Awls, Backing	6	
„ Thong, or Drawing	2	
„ Tug	1	
„ Seat, 2 sizes	4	
„ Garnishing, 2 sizes	4	
„ Stitching, 5	18	
„ Buckling	6	
Awl Handles, 3 sizes	12	
Chisels, Cold, ¾-Inch	1	
Clams ... Pairs	1	
Compasses. 7-Inch ... „	1	
Creases, Single	1	
Screw	1	
Shoulder	1	
Hollow Bones	1	
Head Pins	1	
Hammers, Rivetting 3 lbs.	1	For Splicing.
„ ½ „	1	„ „

IMPLEMENTS AND TOOLS—*continued*.

IMPLEMENTS, ETC.	Number.	OBSERVATIONS.
COLLAR MAKER'S—*continued*.		*With the Store Waggon.*
Hammers, Saddler's	1	With Side Claw.
,, Claw	1	
Irons, Edge	1	
,, Palin, 34-Inch	1	
,, ,, 29 ,,	1	
,, ,, 23 ,,	1	
,, Collar	3	
,, Seat Stuffing, 14-Inch	1	
,, ,, ,, 11 ,,	1	
,, Pricking, Round	1	6 Teeth to the Inch.
,, ,, ,,	1	6 Teeth, Scale of 10 to the Inch
,, ,, Square	1	6 ,, ,, 14 ,, ,,
Knives, Round	1	
,, Head	1	
,, Hand Straight	2	
Leads, Punching, 8-lbs	1	
Mallets, Collar	1	
Boxwood	1	
Marline Spikes, Wood	1	
Needles, Saddler's	100	Assorted.
,, Harness Maker's	100	
,, Collar ,,	18	
,, Quilting	6	
,, Stitching	25	
Nail Claws	1	
Pincers, Saddler's .... Pairs	1	
,, Common .... ,,	1	
Plyers, Flat Nose .... ,,	1	
Rasps, Shoe Maker's	1	
Punches, Trace, Large	2	
,, ,, Small	2	
,, Strap, Large	2	
,, ,, Small	2	
,, Stirrup, Large	2	
,, Bridle, Medium	2	
Rules, 2-Feet	1	Folding in 4.
Scissors, 8-Inch .... Pairs	1	
Seam Turners	1	
Spoke Shaves, Large	1	
Screw-Drivers, 6-Inch	1	
Steels, Butcher's	1	
Thimbles	2	

IMPLEMENTS AND TOOLS—*continued.*

IMPLEMENTS, ETC.	Number.	OBSERVATIONS
WHEELER'S—*continued.*		***With the Spare Gun Carr***
Planes, Smoothing	1	
„ Rebate 1½-Inch	1	
„ Bead ⅜-Inch	1	
Glue Pots and Brushes	1	
Pincers . . . . Pairs	1	
Punches	2	
Rules, 2-Feet	1	
Saws, Hand	1	
„ Tenon	1	
„ Compass	1	
Saw Setters	1	
Oil Stones, Turkey	1	
Rub Stones, 12-Inch	1	
Rag Stones	1	
Wrenches	1	
Screw Drivers, 6-Inch	1	
„ 14 „	1	
Spoke Shaves, 3-Inch	1	
„ 4 „	1	
Squares, Iron	1	
„ Wood, 12-Inch	1	Graduated.
„ „ 9 „	1	
Stock with 24 Bits	1	With Steel Blade.
COLLAR MAKER'S.		*With the Store Waggon.*
Awls, Backing	6	
„ Thong, or Drawing	2	
„ Tug	1	
„ Seat, 2 sizes	4	
„ Garnishing, 2 sizes	4	
„ Stitching, 5 „	18	
„ Buckling	6	
Awl Handles, 3 sizes	12	
Chisels, Cold, ¾-Inch	1	
Clams . . . . Pairs	1	
Compasses. 7-Inch . . . . „	1	
Creases, Single	1	
Screw	1	
Shoulder	1	
Hollow Bones	1	
Head Pins	1	
Hammers, Rivetting 3 lbs.	1	For Splicing.
„ ½ „	1	„ „

IMPLEMENTS AND TOOLS—*continued.*

IMPLEMENTS, ETC.	Number.	OBSERVATIONS.
COLLAR MAKER'S—*continued.*		***With the Store Waggon.***
Hammers, Saddler's	1	With Side Claw.
,, Claw	1	
Irons, Edge	1	
,, Palin, 34-Inch	1	
,, ,, 29 ,,	1	
,, ,, 23 ,,	1	
,, Collar	3	
,, Seat Stuffing, 14-Inch	1	
,, ,, ,, 11 ,,	1	
,, Pricking, Round	1	6 Teeth to the Inch.
,, ,, ,,	1	6 Teeth, Scale of 10 to the Inch
,, ,, Square	1	6 ,, ,, 14 ,, ,,
Knives, Round	1	
,, Head	1	
,, Hand Straight	2	
Leads, Punching, 8-lbs.	1	
Mallets, Collar	1	
,, Boxwood	1	
Marline Spikes, Wood	1	
Needles, Saddler's	100	Assorted.
,, Harness Maker's	100	
,, Collar ,,	18	
,, Quilting	6	
,, Stitching	25	
Nail Claws	1	
Pincers, Saddler's .... Pairs	1	
,, Common .... ,,	1	
Plyers, Flat Nose .... ,,	1	
Rasps, Shoe Maker's	1	
Punches, Trace, Large	2	
,, ,, Small	2	
,, Strap, Large	2	
,, ,, Small	2	
,, Stirrup, Large	2	
,, Bridle, Medium	2	
Rules, 2-Feet	1	Folding in 4.
Scissors, 8-Inch .... Pairs	1	
Seam Turners	1	
Spoke Shaves, Large	1	
Screw-Drivers, 6-Inch	1	
Steels, Butcher's	1	
Thimbles	2	

IMPLEMENTS AND TOOLS—continued.

IMPLEMENTS, ETC.	Number.	DESCRIPTION.
COOPERS.		
Adzes, Gun Metal	[illegible]	For Six Powder Barrels.
Drivers	1	„ „ „ „
Wrenches	[illegible]	„ „ „ „
Adzes, Sharp	[illegible]	
„ Rounding	[illegible]	
Axes	[illegible]	
Bung-Borers, 2-inch	1	
Cross-Stocks, 2-inch	[illegible]	Purchased in Bazaar.
[illegible]	[illegible]	Pail.
Chisels, 2-inch	[illegible]	Six Gallon.
„ [illegible]	[illegible]	Four „
Compasses, 12-inch Pairs	1	
Drivers, Tapering	[illegible]	
„ [illegible]	[illegible]	
Files, Handsaw	[illegible]	
Howels	[illegible]	
Hammers, Riveting, 3 lbs.	[illegible]	
„ [illegible]	[illegible]	
[illegible] Irons	[illegible]	
Jointers	[illegible]	Field Service Pattern.
Jiggers	[illegible]	
Knives, Heading or Drawing	[illegible]	
„ [illegible]	[illegible]	
„ [illegible] or [illegible]	[illegible]	
Pincers Pairs	[illegible]	
[illegible]	[illegible]	
Rules, 2-feet	[illegible]	
[illegible]	[illegible]	
Saws, [illegible]	[illegible]	
„ [illegible]	[illegible]	
„ Taper	[illegible]	
[illegible]	[illegible]	
„ [illegible]	[illegible]	
Shaves, [illegible]	[illegible]	
„ [illegible]	[illegible]	For Casks.
„ [illegible]	[illegible]	
[illegible]	[illegible]	„ Pails.
„ [illegible]	[illegible]	Closed.
[illegible]	[illegible]	

Implements and Tools—*continued.*

IMPLEMENTS, ETC.	Number.	OBSERVATIONS.
TINSMITH'S.		
Awls, Scoring	1	
Bellows ....Pairs	1	
Compasses, 7-Inch........ ,,	1	
Chisels, Cold, 1-Inch by 5	1	
,, ,, ¾ ,, 5	1	
Files, Flat Bastard 12-Inch	2	
Rasps, Half-Round 12-Inch.. .	1	
Grovers, Hand	1	
Hammers, Block..............	1	
,, Hollowing	1	Face 1½ by 1½-Inch.
,, Rounding.........	1	Square Faced 1⅜-Inch.
,, Rivetting 1 lb... ...	1	
,, Pancing 3½ ,, ...	1	
,, Lead 3½ ,, ...	1	Same Pattern as Smith's.
,, Creasing 10 oz.	1	
Irons, Beak Folding 12 lbs.	1	
,, Creasing 11 lbs.	1	
,, Soldering	1	
,, ,, Bottoming....	1	
,, Creasing	1	For Tubes.
Knives, 5-Inch	1	
Leads, 1¼ lbs.	1	
Mallets, Boxwood	2	
Punches, Flat ¼-Inch	1	
,, 3/16 ,, ...	1	
,, Hollow ⅜-Inch	1	
,, ,, 1⅛ ,, ...	1	
,, ,, 1⅝ ,, ...	1	
,, Dub................	1	With Bed for Tubes.
Fire Pots 13½ lbs..............	1	Wrought Iron.
Plyers, Flat ....Pairs	1	
Pincers, Cutting, or Nipping ..	1	
Stakes, Round 2-Inch	1	
,, ,, 1½ ,, ...	1	
,, Tube	1	
Spur Tools	1	
Shears, Stock ....Pairs	1	
,, Snip .... ,,	1	
,, Scotch .... ,,	1	
Squares, Iron	1	Graduated.
Files, Square 9-Inch	1	
Iron Wire . ...oz.	4	No. 10 Gauge.

IMPLEMENTS AND TOOLS—*continued.*

IMPLEMENTS, ETC.	Number.	OBSERVATIONS.
COOPER'S.		
Adzes, Gun Metal	1	For the Powder Barrels.
Drivers	1	„ „ „ „
Wrenches	1	„ „ „ „
Adzes, Sharp	1	
„ Rounding	1	
Axes	1	
Bung-Borers, 3-Inch	1	
Cross-Stocks, 2-Inch	1	Puncheon or Barrel.
„ „ 1¼ „	1	Pail.
Chives, 7¼-Inch	1	Six Gallon.
„ 6¾ „	1	Four „
Compasses, 12-Inch ...... Pairs	1	
Drivers, Upright	1	
„ Kneed	1	
Files, Handsaw	6	
Howels	1	
Hammers, Rivetting, 3¾ lbs.	1	
„ Brad ½ „	1	
Bick Irons	1	
Jointers	1	Field Service Pattern.
Jiggers	1	
Knives, Heading or Drawing	1	
„ Cramming	1	
„ Cleaving or Splitting	1	
Pincers ...... Pairs	1	
Punches, 10-Inch	1	
„ 6 „	1	
Rules, 2-Feet	1	
Stocks	1	
Bits, Dowling	4	
„ Centre 1-Inch	1	
„ „ ¾ „	1	
„ Taper	1	
Handsaws	1	
„ Compass or Turning.	1	
Shaves, 2-Hand	1	
„ Outside	1	For Casks.
„ Inside	1	„ „
„ „	1	„ Pails.
Stones, Rag	1	
„ Oil	1	Cased.
Vices, Screw	1	

IMPLEMENTS AND TOOLS—*continued.*

IMPLEMENTS, ETC.	Number.	OBSERVATIONS.
TINSMITH'S.		
Awls, Scoring	1	
Bellows ....Pairs	1	
Compasses, 7-Inch ,,	1	
Chisels, Cold, 1-Inch by 5	1	
,, ,, ¾ ,, 5	1	
Files, Flat Bastard 12-Inch	2	
Rasps, Half-Round 12-Inch	1	
Grovers, Hand	1	
Hammers, Block	1	
,, Hollowing	1	Face 1⅛ by 1¼-Inch.
,, Rounding	1	Square Faced 1⅜-Inch.
,, Rivetting 1 lb.	1	
,, Pancing 3½ ,,	1	
,, Lead 3⅜ ,,	1	Same Pattern as Smith's.
,, Creasing 10 oz.	1	
Irons, Beak Folding 12 lbs.	1	
,, Creasing 11 lbs.	1	
,, Soldering	1	
,, ,, Bottoming	1	
,, Creasing	1	For Tubes.
Knives, 5-Inch	1	
Leads, 14 lbs.	1	
Mallets, Boxwood	2	
Punches, Flat ¼-Inch	1	
,, 3/16 ,,	1	
,, Hollow ⅜-Inch	1	
,, ,, 1⅛ ,,	1	
,, ,, 1⅜ ,,	1	
,, Dub	1	With Bed for Tubes.
Fire Pots 13½ lbs.	1	Wrought Iron.
Plyers, Flat ....Pairs	1	
Pincers, Cutting, or Nipping	1	
Stakes, Round 2-Inch	1	
,, ,, 1¼ ,,	1	
,, Tube	1	
Spur Tools	1	
Shears, Stock ....Pairs	1	
,, Snip ,,	1	
,, Scotch ,,	1	
Squares, Iron	1	Graduated.
Files, Square 9-Inch	1	
Iron Wire ....oz.	4	No. 10 Gauge.

TRANSPORT.—*Embarkation,—Tonnage.*

The proportion of tonnage allowed for troops embarked on board transports is usually at the rate of two tons for each man. It is understood, however, that this proportion varies with the urgency of the service and the expected duration of the voyage.

TRENCH.—*Artillery,—Fortification,—Ricochet.*

Trenches are either lateral or direct. Direct, when, step by step, they gradually diminish the distance between the besiegers and the besieged,—lateral, when, in every part, they are equidistant, or nearly so, from the saliants of the works, the prolongations of which they embrace. Lateral trenches are called parallels, or places of arms,—direct, zig-zags, approaches, or communications.

Ground is usually broken in the night. It is, therefore, of the utmost importance that advantage should be taken of the enemy's ignorance of the side of attack, to push forward the approaches at least as far in advance as the first parallel, before daylight. Some authors recommend that the operation of breaking ground should commence with the parallel itself, and that the opening of the communications with the depôts in its rear should, if necessary, be postponed until the following morning. By this mode of proceeding, which is decidedly preferable to the other, immediate cover for the guards of the trenches will be obtained, and the ricochet and enfilading batteries may be brought into play at an earlier period of the siege.

If the first parallel could be established at a distance not exceeding four hundred yards from the saliants of the covered-way, important advantages would be thereby obtained. It is, however, generally run at about six hundred yards from those points,—its extent being sufficient to embrace the prolongations of all those works, the artillery of which can be brought to bear upon the approaches. The extremities of this parallel are usually secured either by redoubts or by returns, about thirty or forty yards in length, behind each of which an epaulment is sometimes thrown up as a cover for cavalry. As respects the profile of the parallel, which is itself traced upon the ground by means of white tape or cord, if the garrison be strong, it should be ten feet broad, independent of the banquette,—if it be weak, about seven feet will usually be found sufficient. In either case, its depth, added to the height of its parapet, must be such as to conceal every thing that passes within it from the view of the garrison.

The working parties, by whom the trench is to be excavated, proceed to their stations, by the most convenient routes, in single file, each man carrying a fascine, and being provided with a spade or shovel and a pickaxe. On the arrival of the men at their respective stations, each man deposits his fascine, which is four feet long, on the ground, two feet in advance of, and parallel to, the tracing line,—the space between the tracing line and the line of fascines being left to form the banquette. If the soil be favourable each man should excavate, before the hour of relief, about a cubic yard and a half of the trench, or a portion of it, three feet in depth by three feet six inches in breadth, and, in length, equal to the length of the fascine in his front,—a portion of work which, at the sieges in Spain, the men never failed to perform in three hours, even under a heavy fire.

It is usual to push forward the approaches upon the prolongation of the capitals of the works attacked, as, in those situations, they are least exposed to the enemy's fire, and are, at the same time, furthest removed from the line of fire between the besieged and the besieger's batteries. If, however, these or corresponding advantages do not attend approaches in those situations, they are, by no means, to be preferred to more secure positions.

The usual method of tracing the zig-zags in the dark is by observing, in the day time, some near object, which, being in line with the saliants of the works attacked, may serve as a direction in the night; or, if the night be not very dark, the saliants of the works may themselves be seen above the horizon. Both of these modes of proceeding are, however, subject to uncertainty. It is, therefore, upon a directing plan, or plan on which are laid down the exact positions of the several flanked angles of the works embraced by the first parallel, together with the prolongations of their faces and capitals, alone that dependance can be placed. On this plan, the point at which the first branch of the zig-zags is to commence being marked off, the point at which it is to cross the prolongation of the capital, and that to which it is to extend on the other side of the capital, or the point at which the second branch is to commence, is marked off in like manner, and so on for each branch in succession. Provided with a plan of this description no difficulty whatever can be experienced, even in the darkest night, in tracing the approaches on the ground.

It is possible, by a proper disposition of the troops appointed to cover the operation of breaking ground, to protect and push forward the approaches till they meet the musquetry fire of the covered-way. Arrived at these points, however, their further progress can be covered and protected only by dispositions in their rear. Hence, those points indicate the position of the second parallel, or defensive line; and further, that thenceforward, other defensive lines must be constructed as often as the relative positions of the besieged and the besiegers, in regard to the heads of the several zig-zags, are such that the former can, by a sudden sortie, reach and attack the working parties before the latter can arrive for their protection.

The second parallel, or defensive line, is traced on precisely the same principles as the first, except that—its position being within the effective range of grape and case shot—the more effectually to cover the men on its banquette, its parapet is supported, as are the parapets of all the works in its front, by gabions, or it is otherwise revetted. Good and efficient banquettes are essentially necessary in all the parallels, and it is also desirable that the revetments of such as are more than one hundred and fifty yards distant from the place, should, at intervals, be formed into steps, that the troops, stationed in them for the protection of the working parties, may, on occasion, advance and meet a sortie with their bayonets. In the more advanced portions of the trenches, effective cover from the fire of the besieged is more essential than facility of egress.

On debouching from the second parallel the approaches are pushed forward simultaneously upon all the capitals, till the head of each arrives at a point about midway between its point of departure and the crest of the glacis. Arrived at these points, the safety of the working parties imperatively demands a more proximate protection than the troops, stationed in the second parallel, can afford. Demi-parallels, or places of arms, are therefore constructed in these positions to envelope the branches of the covered way, and to support the besiegers in their ulterior operations.

The fire of the place being too deadly and destructive to admit of the approaches being pushed forward from the second parallel, by the ordinary process, it is thenceforward necessary to resort either to the flying or to the full sap; or occasionally, as was advantageously practised at the Siege of St. Sebastian, to both combined. The mode of proceeding, by means of the flying sap, has been, in part, explained in describing the tracé of the second parallel. It is only necessary further to observe, that, in this operation, the men work in pairs,—two men filling two gabions,—and that, during the peninsula campaigns, no difficulty whatever was experienced in executing, by this process, after dark, any portion of trench that the working parties were sufficiently numerous to line, notwithstanding the heavy fire of the enemy.

If the enfilading and ricochet batteries have produced their expected effect on the defences and fire of the place, the trenches may be pushed forward by the full sap, day and night, without intermission. The sappers appointed to this laborious and hazardous duty are formed into brigades of eight men each, and subdivided into demi-brigades, as only four men can be employed on the sap together, or at the same time. It is also customary to relieve each demi-brigade at the end of an hour, and the brigade itself at the end of six hours. The leading sapper of the first demi-brigade—each sapper taking the lead in his turn—commences the operation. He pierces the parapet of the parallel, or finished portion of the trench at the point of departure, covers the opening by the sap-roller, pushes it before him, places the first gabion in the intended direction, and, keeping himself concealed, fills it with earth as expeditiously as possible. Being thus covered in front and flank, he sinks the trench eighteen inches in every direction, again pushes forward the roller, places a second gabion, fills it, and thus proceeds, placing and filling one gabion after another, until he is relieved. As soon as the first sapper has advanced five feet, or placed and filled the third gabion, the second, third, and fourth follow in sucession, and each, in turn, widens and deepens the trench six inches. Or, the second sapper merely sinks the trench another eighteen inches, while the third and fourth, each in succession, increase its breadth nine inches. By this last method, which is practised in the British service, not only are the sappers more speedily covered than by the former, but they are also enabled to keep pace with each other, as their labour is equalized. The ordinary working parties then enter the trench and enlarge its dimensions according to the prescribed profile.

The third parallel is usually run at the foot of the glacis. Its profile is generally bolder than that of the second. It is also sometimes necessary to construct a fourth parallel, especially if the garrison be very numerous, or if its artillery cannot be silenced.

Tube.—*Artillery.*

The pipes of tubes of all descriptions must pass through a guage two-tenths of an inch in diameter.

Dutch tubes are made of paper; metallic tubes of brass. The pipe papers of the former are cut into rectangles, each five inches and a half in length by two inches in breadth, and the slips for the cups into lengths, each seventeen inches, by four-tenths of an inch. The metallic tube pipes are each three inches in length, and the cups, before stamping, are each one inch in diameter. Metallic tubes are preferred for land: quill tubes for sea service.

The composition is mealed powder mixed up stiff with alcohol, and the tubes, when completed, are packed in bundles, each bundle containing one hundred.

Implements required:—

Guages.
Slitting Engines.
,, Knives.
Scissors.
Knives.

Needles.
Composition Boxes.
Leather Bottoms.
Flannel Dusters.
Wire Prickers.

Materials required to complete 1000 of each of the undermentioned Tubes.

MATERIALS.	Tubes.			
		Quill.		
	Brass.	Common.	Fynmores.	Dutch.
Paper, 24-Pounder Cartridge ..Sheets	5·000	..	7·000	..
„ ½- „ „ „	..	..	..	5·000
„ Fine White .... „	18·000	15·000	20·000	30·000
„ Whited Brown .... „	5·000	5·000	10·000	..
Quills	..	1000	1000	..
Worsted...................... Lbs.	..	·281	·265	..
Brass (in thin Sheets) .... „	25·000	..	..	..
Solder .... „	10·000	..	..	..
Rosin........................ „	2·000	..	..	..
Sal Ammoniac .... „	1·000	..	..	..
Gum Arabic.................... „	..	..	·019	..
Flour...... .... „	..	..	..	1·500
Mealed Powder .... „	4·750	3·000	6·000	2·188
Dutch Thread.................. „	..	..	..	·125
Packing Twine .... „	·313	·250	·750	..
Alcohol ....Pints	2·000	1·000	3·500	1·000
White Charcoal ....Bushels	1·000	..	..	..

Vent.—*Artillery,—Tube.*

The vents of English ordnance, of all descriptions, are two-tenths of an inch in diameter, and it would appear, according to Dr. Hutton and others, to be a matter of indifference, so far as the initial velocity and range of the projectile are concerned, whether the fire be communicated to the centre, rear, or front of the charge.

Brass ordnance is vented with pure copper, and, in consequence of the injury sustained by the iron guns employed at the sieges of Badajos and St. Sebastian in 1812 and 1813, it has been recommended that iron ordnance demanded for siege equipments should, in future, be also vented with copper previous to its being issued.

The recommendation is founded on a series of experiments made at Woolwich in September and October, 1813, with four 24-pounders—two of them having common vents, one a vent of wrought-iron, and the other one of pure copper—to ascertain what number of rounds, iron ordnance of this description loaded with the full service charge, one shot and two junk wads, is capable of sustaining without injury when the firing is incessant.

On the first day one hundred rounds were fired from each gun in six hours and twenty minutes, at intervals of four minutes between the rounds. On the second day, one hundred and fifty rounds were fired from each gun, at intervals of three minutes between the rounds, the rate of firing this day being fifty rounds in two hours and twenty-seven minutes. And, on the third day, the practice of the second was repeated.

The bores of the guns were then—four hundred rounds having been fired from each—carefully examined, and found to be uninjured, except near the seat of the shot, where they were slightly indented. On examining the vents after every twenty-five rounds on the first day, and every fifty, on the second and third, that of copper was found to have resisted the best, no change being perceptible in it till after the first one hundred and fifty rounds had been fired. The common vents failed from the first, and continued to enlarge to the end of the firing, as did that of the wrought-iron, but this last so gradually, that at the end of the first one hundred rounds, the change in it was hardly perceptible. It was also observed, that the injury sustained by the vent was, in every instance, greater at the upper, than at the under surface.

Wad.—*Artillery.*

By the experiments of Dr. Hutton, Lombard, and others, it appears that the initial velocity of the projectile, and consequent range of a piece of ordnance is affected neither by the use of wads, nor by the greater, or less ramming of the charge. Junk wads should therefore only be used in firing red hot shot, or in firing at an angle of depression, and for this last purpose it has been proposed to make use of the caps of prepared paper in which the cartridges are packed.

Wadmiltilt.—*Artillery,—Magazine.*

Length 14 Feet 6 Inches. Breadth 11 Feet 6 Inches.
Weight 50 lbs.

Wheel.—*Axletree,—Carriage.*

Weight, Diameter, etc. of Wheels for Field, Siege, and Transporting Carriages.

Field Carriages.

18-Pounder Guns, and 8-Inch Howitzers.

Diameter 5 Feet. Weight 3 cwt. 1 qr. 4 lbs.

Limbers of 18-Pounder Guns, and 8-Inch Howitzers.

Diameter 3 Feet 10 Inches. Weight 1 cwt. 3 qrs. 14 lbs.

12-Pounder Guns and Limbers, 9-Pounder, and Heavy 6-Pounder Guns, and 24-Pounder Howitzers.

Diameter 5 Feet. Weight 2 cwt. 0 qrs. 14 lbs.

9-Pounder, Heavy 6-Pounder, and 24-Pounder Howitzer Limbers, Light 6-Pounder, and Heavy 3-Pounder Guns and Limbers, and 12-Pounder Howitzers and Limbers.

Diameter 5 Feet. Weight 1 cwt. 3 qrs. 0 lbs.

Mountain-Service Guns and Howitzers, and their Limbers.

Diameter 3 Feet. Weight 0 cwt. 1 qrs. 24 lbs.

Colonial-Service Guns and Howitzers, and their Limbers.

Diameter 4 Feet 4 Inches. Weight 1 cwt. 0 qrs. 8 lbs.

The Ammunition Waggons of the 18-Pounder Battery take the same wheels as its Guns and Howitzer, and all other Ammunition Waggons, and Waggons and Carriages attached to Field Batteries, and Batteries of Horse Artillery take the same class of wheels as the Limbers of their respective Guns and Howitzers.

Siege Carriages.

24-Pounder Guns, and 10-Inch Howitzers.

Diameter 5 Feet. Weight 4 cwt. 0 qrs. 19 lbs.

18 and 12-Pounder Guns and 8-Inch Howitzers.

Diameter 5 Feet. Weight 2 cwt. 1 qr. 8 lbs.

Limbers of Siege Guns and Howitzers.

Diameter 3 Feet 10 Inches. Weight 1 cwt. 3 qrs. 5 lbs.

Transporting Carriages.

Devil Carriages.

Diameter (Hind) 7 Feet. Weight 5 cwt. 2 qrs. 12 lbs.
„ (Fore) 5 „ „ 2 „ 3 „ 4 „

Platform Waggons.

Diameter (Hind) 5 Feet. Weight 2 cwt. 3 qrs. 4 lbs.
„ (Fore) 4 „ „ 2 „ 1 „ 2 „

Flanders Waggons, and Pontoon Carriages.

Diameter (Hind) 5 Feet 2 Inches. Weight 1 cwt. 3 qrs. 0 lbs.
„ (Fore) 4 „ 2 „ „ 1 „ 1 „ 19 „

Ball Cartridge Waggons.

Diameter 5 Feet. Weight 1 cwt. 3 qrs. 0 lbs.

Sling Carts.

Diameter 5 Feet. Weight 3 cwt. 3 qrs. 0 lbs.

Hand Carts.

Diameter 4 Feet 4 Inches. Weight 1 cwt. 0 qrs. 8 lbs.

Trench Carts.

Diameter 4 Feet 2 Inches. Weight 1 cwt. 1 qr. 24 lbs.

WINDAGE.—*Shot,—Shell,—Gunnery.*

If, according to Dr. Hutton, the windage of a piece of ordnance, or, the difference between the diameter of its bore, and that of its projectile,—be equal to one-twentieth of its calibre, from one-fourth to one-third of the force of the charge, or of the elastic fluid, generated by the ignition of the powder, escapes and is lost.

It is also to the want of correspondence, arising from the windage, between the axis of the bore, and that of the projectile, and the consequent unequal pressure of the elastic fluid on the surface of the shot, that artillerists attribute the injuries sustained by the bore of the gun, and the want of accuracy and precision which is occasionally observed in their practice.

The loss in the initial velocity, and range of the projectile, consequent on the escape and loss of the elastic fluid, can, within certain limits, be supplied by a proportionate increase in the charge, but the more important defects, the injury to which the bore of the gun is exposed, and the want of accuracy and precision in its fire, can be remedied only, by a reduction, to the utmost possible limit, in the windage itself.

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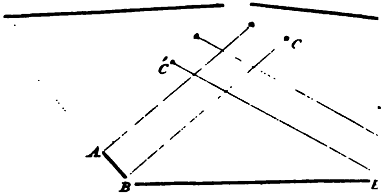

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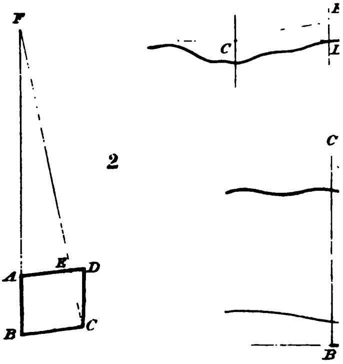

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